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NOTICE.

IN future these ARCHIVES will be published at intervals of as nearly three months as possible. The number of pages of each issue will be reduced, four issues, instead of two, constituting a volume. About four-fifths of the space will be devoted to original papers, the remainder to reviews of the current ophthalmological and otological literature. For the English Edition, Drs. E. Gruening, of New York, and C. J. Blake, of Boston, will assist, as associated editors, in conducting the journal, the former in the ophthalmological department, the latter in the otological. Further particulars will be given in a prospectus to be issued with the next number.

H. KNAPP.

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OPHTHALMOSCOPIC OPTOMETRY, AND DESCRIPTION OF A NEW OPHTHALMOSCOPE.

By H. KNAPP.

Most of the recent improvements in the construction of ophthalmoscopes have for their object a convenient arrangement of an increased number of auxiliary or correcting lenses. Such lenses are indispensable to the examination in the erect image, and useful to the examination in the inverted image. In addition to that, they enable us to determine the anomalies of refraction independently of the answers of the patients, many of whom are unable to make any answers at all. The use of the auxiliary glasses being so important and varied, it is easily understood what gain in accuracy and time will be derived from their appropriate and convenient arrangement. The simple concave mirror is now almost generally adopted. By various contrivances auxiliary lenses were added to it: Liebreich connected with it a fork-like holder, into which small lenses could be inserted. He limited the number of auxiliary lenses to five. As the want of an increased number was soon felt, I had, about ten years ago, a complete trial case of small spectacle glasses made, which were inserted into Liebreich's holder whenever I wanted to determine errors of refraction with the ophthalmoscope, or examine ametropic people in the upright image. This

answered all purposes, but was tiresome work and added to the expense of the ophthalmoscope the much greater expense of a complete set of trial-glasses. To avoid this, H. D. Noyes enlarged the holder behind the mirror so as to fit the glasses of the ordinary trial cases of Paetz and Flohr, or Nachet, but he sacrificed the neatness which rendered the small Liebreich ophthalmoscope so handy.

Another arrangement, introduced by REKOSS of Koenigsberg, and frequently used, is a rotating disk behind the mirror. In its ordinary form it admits of a small number of glasses only, and becomes unwieldy if a greater number is inserted, as is the case with the ophthalmoscope of H. COHN of Breslau, the disk of which is 3 inches in diameter. When the disk is fastened in the centre on a pivot, it soon becomes loose and thereby inconvenient. The best application of Rekoss' disk was made, 4 years ago, by E. G. LORING of New York. He placed 23 glasses, half positive and half negative, into three separate disks, which could one after the other be inserted into a ring behind the mirror. By lateral springs, connected with the ring and pressing upon the border of the disks, the disks are held in their places, and can be easily turned.

The workmanship of the optician, H. W. HUNTER, of New York, deserves all praise. The instrument which I had in daily use these four years has never been repaired, and is still in perfect condition. Loring's mirror has a sufficient number of glasses for nearly all practical purposes, namely: + 3, 4, 5, 6, 7, 8, 10, 12, 16, 24, 48, and − 2, 3, 4, 5, 6, 7, 8, 10, 12, 16, 24, 48.

One aperture in one disk remains empty. This arrangement reduces the mechanical labor required in an ophthalmoscopic examination to the alternate insertion of three disks, and to the passage from one lens to another by turning the disks.

The examination with the ophthalmoscope is of such paramount importance to the eye surgeon, that he should have all possible conveniences to do it efficiently, comfortably, and expeditiously. I examine nearly all my patients with the ophthalmoscope, even if there be no suspicion of an intra-ocular difficulty. It gives me more certainty of diagnosis, and the patient the satisfaction of receiving careful attention. In order to do this with the least inconvenience and in the shortest time, I have my ophthalmoscope room adjoining the consultation room, and provided with an Argand gas burner mounted on a bracket movable in all directions. Thus, patients may be examined either standing or sitting. Standing saves a good deal of time. In the examination in the upright image, the physician should look with his right eye into the right eye of the patient, and with his left eye into the patient's left, at a distance which need never be greater than one inch and a half to two inches. To do this, we must either change the position of the lamp (which is commonly inconvenient), or take the patient to the other side, which is more easily done in standing than in sitting.

I rarely finish an ophthalmoscopic examination without determining the state of refraction of the eye. This can be readily done with Loring's mirror for emmetropic and moderately hyperopic patients; but when there is no hyperopia and we wish to determine whether there is myopia, and of what degree, we have to insert another disk, and when the degree of myopia or hyperopia is considerable, we must change the disk again. The same process has to be gone through when exudations or depressions render the relief of the background of the eye

irregular, provided we care to know the amount of such elevations and depressions. As all this consumes time; we are apt to omit, in many a case, an exceedingly important mode of investigation, contenting ourselves with the examination in the inverted image, just as we are liable to omit, in many a case, the examination with the ophthalmoscope altogether when we have no more convenient accommodations for it than the darkening of the consultation room by closing shutters or curtains. These requirements of the daily practice led me to the construction of an ophthalmoscope with which a complete set of auxiliary lenses is in constant connection, without detriment to the neatness and convenience of the instrument. Its reflector is the ordinary concave mirror, as in Liebreich's, Loring's, and other instruments. It is screwed on a thin, plain plate of metal. (See Fig. 1.) On the other side of this metal plate lie two disks (Fig. 2. A), of which the upper contains the convex lenses, 2, 3, 4, 6, 8, 10, 12, 14, 17, 20, 24, 33, 48, and the lower a like series of concave lenses.

The accompanying figures are taken from the first copies of the instrument, which I exhibited at the meeting of the American Ophthalmological Society in July, 1873. In these first instruments the series of lenses began with No. 3, instead of No. 2.

Each disk rotates on a central pivot, and presses upon a delicate spring, having at its end a small point-like elevation. Opposite each lens is a point-like depression, into which the point of the spring falls when the disk is rotated. These depressions are not so deep, however, as to prevent the disk from being easily turned,

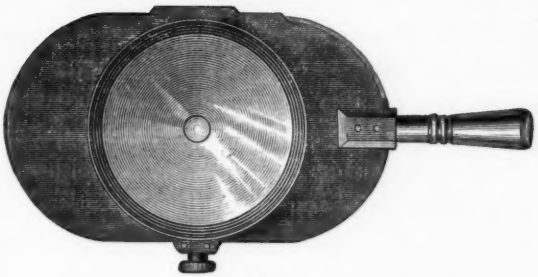

Fig. 1.

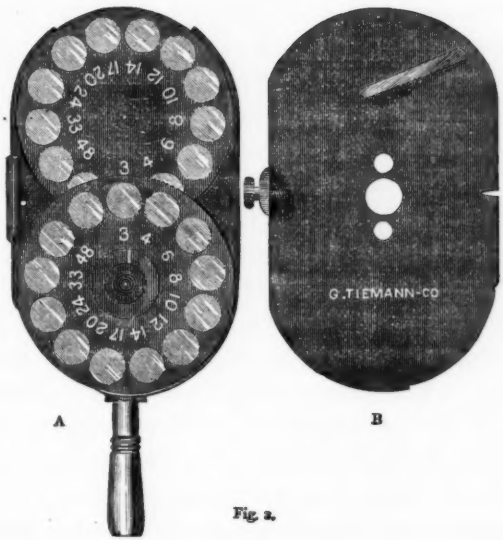

Fig. 2.

yet deep enough to cause the arrest of the disk, when the centre of the auxiliary lens through which we want to look is just opposite the centre of the aperture in the mirror. The disks are held in position and covered by a thin removable metal plate (cover), on the anterior (looking toward the patient) surface of which is a delicate straight spring (Fig. 2. B) which presses upon the upper disk, whereas the lower disk is steadied by a spiral spring in the centre of its posterior surface (Fig. 2. A). On one side of the metal cover (Fig. 2. B) is a notch fitting over a point on the other side of the body of the instrument, whereas on the opposite edge of the notch is a small perforated projection through which passes a thumb-screw, fastening the cover to the body (Fig. 3) opposite the aperture in the mirror.

The margin of the lower disk overlaps the margin of the upper (Fig. 2) in such a way that each positive glass can be covered by each negative glass, and the inverse. Thus combinations are formed which enable us to obtain a very extensive series of test-glasses.

The rotation of the disks is exceedingly easy. When the instrument is closed (Fig. 3), the margin of the upper disk projects over the upper edge of the metal plates, whereas the margin of the lower disk projects on both sides over the lower end of the plates. Each disk can be rotated to the right or left by a slight touch of the finger. This arrangement enables us to *change the glasses without removing the instrument from the eye.* The lower disk is rotated with the forefinger of the hand which holds the instrument, whereas the upper disk is turned with the forefinger of the other hand.

The cover has three round apertures (Fig. 3). The larger, central one is opposite the aperture in the reflector, and serves for the passage of the rays of light from the eye examined into that of the physician. The correcting lenses, when used, lie between this central aperture of the cover and the aperture of the reflector.

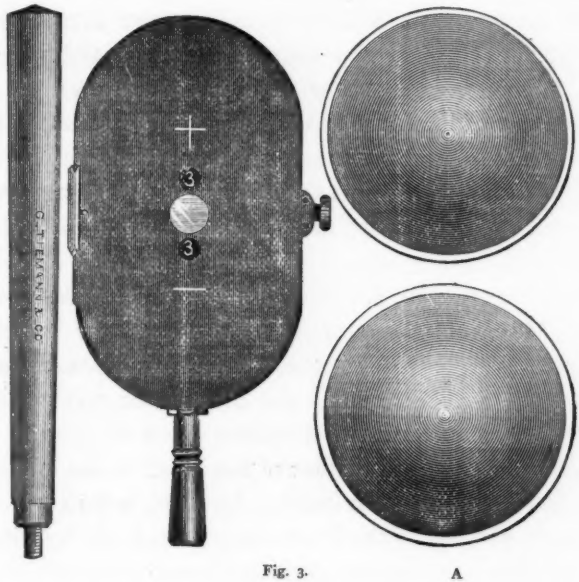

Fig. 3. A

In order to know what lenses are used, two smaller round openings are placed the one above and the other below the central aperture in the cover. Through these smaller apertures we read the numbers of the auxiliary lenses which are behind the opening in the mirror. Whether these lenses are positive or negative, is indicated by the + and – signs placed near the

smaller apertures (Fig. 3). *The cover prevents the auxiliary glasses from being easily soiled.* If, after prolonged use of the instrument, dust collects on the lenses, the cover can be removed, the disks taken out and cleansed. This cleansing is very simple, and rarely needed, as a little dust does not materially interfere with the purity of the ophthalmoscopic image.

A short ivory handle (Fig. 3) screws into a brass socket fastened to the mirror, and two larger lenses (+ 2 and + 3 or other numbers, according to the pleasure of the physician) are added (Fig. 3. A). The parts of this ophthalmoscope are represented by the accompanying figures in their natural sizes. The whole instrument is contained in a case a little larger than half the size of Fig. 3, viz., 3″ 9‴ in length, 2″ 7‴ in width, and 11‴ in thickness. The workmanship of the instrument (by Miller Bros., 1223 Broadway, New York) is of a high order as to neatness, accuracy, and durability. With the handle, the instrument weighs two ounces, and its greatest thickness from the rim of the reflector to the back surface of the cover is five millimetres (two-eighths of an inch). Its price is $40.

As to the *use* of the instrument I need say but little. Every one who knows ophthalmoscopy can use the instrument and will be familiar with it in a few days. The rotations may be to the right or to the left, till the number of the desired glass shows in the small aperture. Commonly the examination is begun without any auxiliary glass, namely for the investigation of the refracting media. After that, the fundus is explored in the inverted image. Near-sighted observers do this

without an auxiliary glass, but emmetropic, presbyopic, and hyperopic observers are in the best optical conditions by placing a convex glass behind the mirror, thus rendering themselves artificially myopic, which should be of the degree of about $\frac{1}{10}$ or $\frac{1}{8}$ the ordinary visual distance for looking at fine objects. The advantages of placing a convex glass behind the mirror are as follows: 1, the observer, being able to go nearer to the examined eye, sees the image in a greater intensity of illumination; 2, he can relax his accommodation; 3, he sees the image enlarged by the magnifying power of the convex lens. I have always been in the habit of placing +10 behind the mirror, and using +3 as the objective lens. This is a very convenient combination, and magnifies the inverted image to about three-quarters of the diameter of the erect image.

To render the new ophthalmoscope as convenient as possible, I had the lens +10 placed between the empty aperture and the lens +2 instead of between the lenses +8 and +12. The reason of this displacement is that I begin, as above mentioned, ophthalmoscopic examinations with the investigation of the refractive media, using the mirror unaided; then I examine the fundus in the inverted image, using +3 as objective and +10 as ocular. This completes the examination in the majority of cases, and therefore I want the ocular which I constantly use for the inverted image to be placed next to the empty aperture in the disk. This arrangement, which has no other advantage than to save time, I recommend to every emmetropic observer who is not yet presbyopic. The employment of a convex

ocular, though not unknown, deserves to be more extensively adopted and appreciated. Messrs. Miller Bros. will place +10 or any other number near the empty aperture, if desired; if not, the lenses follow one another in their regular order.

The series of test-glasses represented by the two disks answers all practical purposes. I chose 48 as the weakest glass, as we hardly prescribe weaker spectacles. The ophthalmoscopic discernment of a refractive interval of $\frac{1}{48}$ seems to be sufficiently nice, yet it is not the limit of this mode of investigation, for we are able to distinguish $H\frac{1}{33}$ from $H\frac{1}{24}$ which represents a refractive interval of $\frac{1}{88}$; we can distinguish even $H\frac{1}{24}$ from $H\frac{1}{20}$, which is a difference of $\frac{1}{120}$. If, in future, a greater cultivation of the method of determining the state of refraction with the ophthalmoscope—which may be termed "*Ophthalmoscopic Optometry*"—should require a weaker glass, + 96 and − 96, or other numbers, might be added to the instrument without making it inconvenient. Should we, even now, need a weaker number than 48, we can easily obtain it with the present instrument by combining a convex number with a concave one of different refractive power; for instance + 33 in combination with − 48 gives + 106; and − 33 with + 48 gives, of course, − 106. By such combinations we may obtain a series of glasses of great variety, yet is it more convenient to have the numbers which are most in use always ready at hand, without being obliged to resort to combinations. It saves time, the great factor in all our pursuits, and that one over which we have no control.

I give here the series of lenses which I have found to be most appropriate, and add the difference or the interval of refraction between every two successive numbers:

2	3	4	6	10	12	14	17	20	24	33	48
	6	12	24	40	60	84	79	113	120	88	106

It is easily understood that the combination of two successive glasses, if the one be positive and the other negative, results in a lens the power of which is equivalent to the interval of refraction between the two glasses, and will be a collective lens if the stronger glass be positive, but a dispersive lens if the stronger glass be negative. The intervals from No. 8 to No. 48 are small enough to need no combinations, and these are the numbers most frequently required, whereas the stronger numbers are less used. Yet they are necessary, and the lenses enumerated above are not sufficient for the requirements of practice. In highly myopic, and in highly hyperopic eyes it may be of importance accurately to study, with the ophthalmoscope, minute changes in the fundus oculi, or to determine the degree of ametropia. In order to do this we have to resort to combinations, of which our instrument admits a great number, more than sufficient for all purposes.

The following table represents a series of suitable combinations, showing, at the same time, the refractive intervals between the higher numbers contained in the ordinary trial cases, and how near the optical value of a

combination approaches that of the corresponding number in the ordinary series of test-glasses.

The + sign in the last column indicates how much weaker, the — sign how much stronger the combination is than the corresponding number of the ordinary series. The addition of the refractive powers expressed by the two last columns is equal to the refractive power of the numbers in the first column.

Ordinary Series.	Refractive Interval.	Combination in Ophthalmoscope.	Real Value of Combination.	Refractive Difference between Value of Combination and the Corresponding No. of the Ordinary Series.
+ 2		....	....	....
	18			
+ 2¼		+ 2 — 17	+ 2$\frac{4}{16}$	— 306
	22½			
+ 2½		+ 2 — 10	+ 2½	∞
	27½			
+ 2¾		+ 2 — 8	+ 2$\frac{8}{8}$	+ 88
	33			
+ 3		....	....	....
	39			
+ 3¼		+ 3 — 48	+ 3$\frac{1}{3}$	+ 65
	45½			
+ 3½		+ 3 — 20	+ 3$\frac{9}{17}$	— 420
	52½			
+ 3¾		+ 3 — 14	+ 3$\frac{9}{11}$	— 210
	60			
+ 4		....	....	....
	36			
+ 4½		+ 4 — 33	+ 4$\frac{8}{10}$	— 396
	45			
+ 5		+ 4 — 20	+ 5	∞
	55			
+ 5½		+ 4 — 14	+ 5$\frac{3}{8}$	— 308
	66			
+ 6		....	....	....
	42			
+ 7		6 — 48	6$\frac{6}{7}$	— 336

It is evident that a like series of negative lenses is obtained by reversing the + and – signs in the third column.

If an emmetropic observer, or an ametropic one who has rendered himself emmetropic by using the proper glass, looks from a distance of about one inch, without a correcting lens, and with relaxed accommodation into an eye, and sees the details of its background indistinctly, the examined eye is either myopic or hyperopic. Without moving the ophthalmoscope he then turns, with the index of the hand which holds the instrument, the lower disk in such a way that the concave lenses follow one another from the weakest to the stronger numbers. If the details of the fundus become clearer, the eye examined is myopic, and the degree of M is found when the weakest glass with which the fundus appears distinct is behind the aperture in the mirror. If, on the other hand, the details of the fundus grow more indistinct when the lower disk is employed, the eye examined is hyperopic. The lower disk is now turned in the opposite direction till the empty aperture is again behind the opening in the mirror, the ophthalmoscope is taken into the other hand, namely from the right into the left if the patient's left eye is examined, and the inverse, and then the upper disk is turned with the forefinger of the first hand. This can likewise be done without taking the instrument from the eye. The turning begins at No. 48 and proceeds to the stronger numbers till the strongest glass is found with which the details of the fundus appear perfectly distinct. This glass determines the degree of H.

Another procedure, by which we may as well first

examine whether the eye is hyperopic, is, perhaps, still more convenient, not requiring the mirror to be passed from one hand into the other. In examining, for instance, the left eye of a patient, we hold the mirror with our right hand in front of our left eye, while the two last fingers of our left hand rest upon the patient's forehead, and our left index finger, touching the edge of the upper disk, and the left thumb, touching the edge of the lower disk, rotate the disks at pleasure. Every one will easily find out a method which is convenient to himself.

Ophthalmoscopic optometry has two objects: 1, the determination of ametropia independently of the statements of the patients, and 2, the measurement of elevations and depressions in the background of the eye.

Perfect relaxation of accommodation on the part of the observer is the first requisite of a correct determination, while the patient is directed to abstain from any accommodative effort by looking into the distance or into vacancy.

As we ascertain the degree of ametropia by measuring the distance of the far-point of the range of accommodation from the cornea, or the anterior principal, or the anterior nodal plane of the eye, it is easily understood that, in determinations by the ophthalmoscope, the distance of the correcting glass from the examined eye has to be added to the number of the concave lens with which the degree of myopia is ascertained, whereas it has to be subtracted from the number of the convex glass with which we ascertain the degree of hyperopia. If, for instance, — 12 be the weakest glass with which an observer, who holds his mirror one inch from the eye

of the patient, sees the fundus clearly, the degree of myopia is not $\frac{1}{12}$ but $\frac{1}{13}$; on the other hand, if + 12 be the strongest positive glass with which he sees the fundus of another patient's eye, the degree of hyperopia is $\frac{1}{11}$. Ametropic observers have, of course, to take the degree of their ametropia into account. The simple procedures to do this are too easy to be dwelt on in this place; besides, they are fully explained in MAUTHNER'S *Lehrbuch der Ophthalmoscopie, Wien,* 1868, p. 165, etc. As there is, however, some reckoning required for every ophthalmoscopic determination done by ametropic observers, I would recommend them to have the glass which corrects their ametropia inserted additionally into one or both disks, namely into both, if it be a number not found in the series given there. An observer of $M\frac{1}{3}$ or $H\frac{1}{3}$, for instance, I would advise to have − 9, respectively + 9, inserted between 48 and 0 into each disk. He is then able to determine the state of refraction of each eye without ciphering, and just as conveniently as an emmetropic observer. If his degree of ametropia is represented by a glass in one disk, he should have the same number additionally inserted into the other disk. He will then gain another opening in the first disk which may be filled by any glass he desires. An astigmatic observer should have an appropriate glass additionally inserted into each disk in the same manner as an ametropic observer, and in case his astigmatism be compound, the additional glass should, of course, correct both his astigmatism and his ametropia. Miller Bros. will make all these arrangements on special request.

The second object of ophthalmoscopic optometry, *the measurement of elevations and depressions in the fundus oculi,* is accomplished by determining in the erect image the states of refraction of the crest and the basis of an elevation, or the margin and the bottom of a depression. Since the optical apparatus in one and the same eye remains unchanged during the examination, the differences in the state of refraction of different parts in the fundus may be found by calculation. I described this method of ophthalmoscopic determination of the relief of the background of the eye at the *Congrès International d'Ophthalmologie,* in Paris, 1867 (see the *Compte-Rendu* of that meeting, p. 165, etc.), and published a table for that purpose in my treatise on the Intra-ocular Tumors (p. 106, English translation). L. MAUTHNER, too, described the same method in his book on Ophthalmoscopy (1868, p. 206, etc.), and E. G. LORING, in an excellent paper: *Determination of the Optical Condition of the Eye by the Ophthalmoscope, with a new Modification of the Instrument for that purpose. Am. Journ. of the Medical Sciences.* 1870, p. 323, etc.

The method is, indeed, nothing but the ophthalmoscopic application of the determination of the length of the ocular axis from known degrees of ametropia.

The calculation is as follows: If we apply the general dioptric formula $\frac{F_1}{f_1} + \frac{F_2}{f_2} = 1$ to the eye, and employ for the anterior and posterior principal focal lengths F_1 and F_2, the values $F_1 = 15$ mm. and $F_2 = 20$ mm., according to Listing's reduced eye, we obtain, by ophthalmoscopic observation two conjugate focal lengths, f_1 and f_2. The luminous object is the background of the eye, its image is seen with

the ophthalmoscope, and its position, respecting its conjugate focal distance, is determined by the correcting lens. If we call the conjugate focal distance of the image f_1, and the conjugate focal distance of the luminous object f_2, we determine f_1 by ophthalmoscopic observation, and find f_2 by calculation.

The above-mentioned general dioptric formula,

$$\frac{F_1}{f_1}+\frac{F_2}{f_2}=1$$

transforms into

$$f_1=\frac{f_2 F_1}{f_2-F_2}.$$

If we deduct F_1 from both sides of the equation, namely,

$$f_1-F_1=\frac{f_2 F_1}{f_2-F_2}-F_1$$

and reduce this expression, we obtain

$$f_1-F_1=\frac{F_1 F_2}{f_2-F_2}.$$

f_1-F_1 in algebraic language signifies the distance between the first conjugate and first principal focal points, and f_2-F_2 means geometrically the distance from the second conjugate to the second principal focal point. Let us put $f_1-F_1=l_1$, and $f_2-F_2=l_2$, the above formula reads: $l_1 l_2=F_1 F_2$.

This formula and its deduction are taken from Helmholtz's *Physiologische Optik*, p. 49. For the convenience of calculation we write it:

$$l_2=\frac{F_1 F_2}{f_1-F_1}$$

because f_1 changes with every auxiliary glass. f_1, as we have seen above, does not exactly represent the principal focal length of the auxiliary glass, but its distance from the eye has to be added in cases of myopia, and deducted in cases of hyperopia. This distance may be reduced to 20 millimetres. In examining, in the erect image, the patient's right eye with my right eye, and his left with my left, the mirror can, without inconvenience, be held so near the patient's eye that the auxiliary lens is 14 to 20 mm. distant from the first principal plane, that is, the middle of the anterior chamber of the patient. The mirror then touches the patient's eyebrow, and thus is invariably at the same distance from the examined eye, whereas this distance is apt

to vary in different observations, if the mirror has no point of rest on the patient's as well as on the physician's orbital margins. If the mirror is held at some distance from the eye under examination, this distance has to be measured for every available observation; but if one edge of the mirror touches the brow of the patient, the distance of the correcting glass from the anterior principal plane of the examined eye may with sufficient accuracy be assumed to measure 20 mm., which quantity has been used in the calculation of the subsequent table.

I may still remark that, if l_2 is found positive, it lies behind the posterior principal focal plane; if negative, it lies in front of it. *As the table is intended to be a* HELP FOR PRACTICE, *the first column indicates the auxiliary*, i.e., *correcting glass, with which the determination is made*, but l_2 *is computed from the real degree of ametropia*, that is as approximatively as it can be determined with the lenses which, thus far, are at our disposition, and, as is known, are all more highly numbered than their focal lengths would indicate; for instance, No. 36 is in reality $33\frac{1}{4}$; 20 is $18\frac{1}{2}$, 14 is 13, 9 is $8\frac{1}{2}$, etc.

The following table (on page 19) will make it easy to *measure the height of elevations, and the depth of depressions in the background of the eye.* If the eye be emmetropic, the quantity corresponding to each auxiliary glass at once indicates in millimetres the elevation or depression of a diseased part. If the eye be hyperopic or myopic, the degree of H or M may first be determined, and afterward the refractive condition of the part, the elevation or depression of which we want to measure. The difference in the refractive conditions of these two determinations refers to two points, situated on the anteroposterior diameter of the globe. Their distance from each other can easily be computed by referring to the table. For instance, an eye, the fundus of which is seen with + 24, is affected with a small intra-

(*To be continued on page 20.*)

TABLE

Indicating the ophthalmoscopic determination of the shortening, resp. elongation of the ocular axis by means of positive, resp. negative auxiliary lenses.

Number of Glass.	Obtained by Combination of	Shortening.	Elongation.
± 2	.....	6.12	5.08
± $2\frac{4}{15}$	± 2 ∓ 17	4.93	4.23
± $2\frac{1}{2}$	± 2 ∓ 10	4.80	4.14
± $2\frac{2}{3}$	± 2 ∓ 8	4.27	3.90
± 3	.....	3.95	3.49
± $3\frac{1}{3}$	± 3 ∓ 48	3.68	3.28
± $3\frac{9}{17}$	± 3 ∓ 20	3.32	2.99
± $3\frac{9}{11}$	± 3 ∓ 14	3.05	2.78
± 4	.....	2.91	2.65
± $4\frac{1}{2}\frac{6}{9}$	± 4 ∓ 33	2.63	2.42
± 5	± 4 ∓ 20	2.31	2.14
± $5\frac{3}{5}$	± 4 ∓ 14	2.05	1.92
± 6	.....	1.91	1.80
± $6\frac{6}{7}$	± 6 ∓ 48	1.62	1.56
± 8	.....	1.42	1.36
± 10	.....	1.13	1.09
± 12	.....	0.94	0.91
± 14	.....	0.80	0.78
± 17	.....	0.66	0.65
± 20	.....	0.56	0.55
± 24	.....	0.467	0.459
± 33	.....	0.339	0.335
± 48	.....	0.232	0.230

ocular tumor the crest of which is seen with + 6. + 6 corresponds to a shortening of the ocular axis of 1.91 mm., + 24 to a shortening of 0.47. By subtraction we obtain 1.44 mm. as the height of the tumor. If the eye had shown $M\frac{1}{24}$ instead of $H\frac{1}{24}$, and the crest of the tumor had shown as before, $H\frac{1}{6}$, the elongation of the optical axis corresponding to $M\frac{1}{24}$, viz., 0.46 mm., should have been added to 1.91. Then the height of the tumor would have been 2.37 mm. This sort of calculation is so easy to understand that I need give no other examples. The two sets of glasses, however, enable us to determine elevations or depressions without resorting to any calculation, by simply referring to the foregoing table. We determine first either the greatest elevation or the greatest depression of that portion of the fundus the height or depth of which we want to ascertain. For instance, the crest of a tumor, with relaxed accommodation, is seen with + 6. We leave + 6 in its position behind the aperture of the mirror, and diminish its effect by placing concave glasses of increasing strength over it until we see distinctly the basis of the tumor, *i.e.*, the fundus oculi. Suppose this is the case with − 8, then it is clear that the eye is hyperopic. Looking up the shortening which corresponds to + 8, we find 1.42 mm., or very nearly the same quantity which we found before by subtraction. The values thus obtained are sufficiently accurate for the weaker numbers only, namely from 8 to 48, since for the stronger numbers the shortening by a certain positive glass differs too much from the elongation by a negative glass of the same focal length or the same number. For the

stronger numbers this method of leaving one glass in position and determining the optical condition of the other surface with the other disk, could be employed only with glasses which are not obtained by combination, viz., 2, 3, 4, 6. The refractive intervals between these glasses, and consequently the amount of shortening or elongation of the optical axis corresponding to them, is so great that determinations made with these glasses alone are not sufficiently accurate. The shortening with + 2 is 6.12 mm., that with + 3 is 3.95 mm. This is too great an interval, and therefore the necessity of intermediate numbers. In general, the method of determining independently the optical conditions of various points in the fundus, and the addition or subtraction of the values corresponding to their location as found in the table, is to be employed for the measurement of high elevations and deep depressions, whereas the other method of determining one surface with a glass of one disk, which is left in position, while the other surface is examined with the other disk, is available and preferable in cases of lesser elevations or depressions. In the great majority of instances we have to deal with elevations or depressions of moderate extent, namely exudations and excavations, and therefore the simpler method of determination admits of more frequent application.

The shortening of the optical axis relating to convex glasses, as stated in the foregoing table, has no reference to the *aphakial eye*, its optical constants being different from those of the ordinary eye. As elevations and depressions: exudations, excavations, tumors, etc.,

may occur in the aphakial as well as in the ordinary eye, I shall arrange a table also for the aphakial eye. The calculation is done according to the formula we used for the ordinary eye: $l_2 = \frac{F_1 F_2}{f_1 - F_1}$. The values of F_1 and F_2 are derived from Helmholtz's and my own measurements of the radius of curvature of the cornea. They are $F = 22.6$ mm.; $F_2 = 30.3$ mm. (See *I. H. Knapp: Die Krümmung der Hornhaut.* Heidelberg, 1859, p. 34.

The use of the *following* table (see next page) seems to need no explanation.

When this paper was finished, I received the September number of *Zehender's Klinische Monatsblätter*, which contains a short notice, accompanied by a drawing, of a new ophthalmoscope by Dr. L. Von Wecker, of Paris. Below the aperture in the mirror of that instrument is a disk which has, near its edge, fourteen concave and ten convex glasses, and is moved by means of a central cog-wheel, from which a stem runs half an inch down the handle. This mechanism admits of the change of glasses without removing the instrument, which the author claims to be of great importance. It is an advantage, providing that the mechanism works well. Though it may be hasty to criticise an instrument without having tried it, I will not withhold some remarks bearing on the usefulness of this instrument in general. If the drawing which accompanies the description illustrates the ophthalmoscope in its natural size, the diameter of the aperture in the mirror measures only 1.5 mm. and that of the auxiliary lenses 2.5 mm. I thought that $3\frac{3}{4}$ mm.

(*Continued on page 24.*)

TABLE—*Indicating the ophthalmoscopic determination of elevations or depressions in the background of* APHAKIAL EYES.

Number of Convex Glass.	Obtained by Combination.	Position of Fundus in front of 2d princ. Focal Plane.
2	.....	12.11 mm.
$2\frac{4}{15}$	+ 2 − 17	10.73 "
$2\frac{1}{2}$	+ 2 − 10	9.75 "
$2\frac{2}{8}$	+ 2 − 8	9.18 "
3	.....	8.19 "
$3\frac{1}{8}$	+ 3 48	7.69 "
$3\frac{9}{17}$	+ 3 − 20	7.19 "
$3\frac{9}{11}$	+ 3 − 14	6.48 "
4	.....	6.19 "
$4\frac{14}{33}$	+ 4 − 33	5.46 "
5	+ 4 − 20	4.98 "
$5\frac{3}{8}$	+ 4 − 14	4.45 "
6	.....	4.16 "
$6\frac{4}{7}$	+ 6 − 48	3.65 "
8	.....	3.13 "
10	.....	2.51 "
12	.....	2.10 "
14	.....	1.80 "
17	.....	1.48 "
20	.....	1.26 "
24	.....	1.13 "
33	.....	0.77 "
48	.....	0.53 "

for the hole in the mirror, and 6 mm. for the lenses were the smallest dimensions which the convenience of use and the very object of the instrument would admit. An ophthalmoscopic examination of the *anatomical* conditions of the eye could be done, and, perhaps, advantageously, with a mirror having a narrower opening than four millimetres, providing that the rays of light emerging from the eye examined impinge upon the mirror at angles not too far from 90 degrees. But when the mirror is held in such a way as to cross the visual line of the observer at an angle more or less acute, the aperture in the mirror is virtually diminished, its projection becoming an ellipse, the small axis of which is shortened in proportion to the slanting of the mirror. This virtual diminution is increased by the metal borders in which the auxiliary lenses are set. An ophthalmoscope which does not admit of easy movements, especially in lateral directions, is not convenient, since it obliges us to place the patient, ourselves, and the lamp in a more or less fixed position. The freedom of movements which the small ophthalmoscope admits of is of great advantage, enabling us to follow up the details of the fundus by moving our heads.

Another drawback which cannot fail to result from a small opening in the mirror is its *action as a diaphragm or stenopæic apparatus*, which, by cutting off the circles of dispersion, prevents us from nicely recognizing the errors of refraction. For that reason Wecker's instrument appears deficient in the very object for the sake of which it was invented.

The ophthalmoscope which I have above described

has now been used more than four months by myself and others, and has given general satisfaction. No faults or drawbacks, either in its design or workmanship, have manifested themselves, or have been pointed out to me. A set of auxiliary lenses, sufficient in themselves for all ordinary purposes, and capable of satisfying all imaginable demands, by admitting of numerous combinations; a mechanism, at the same time durable and working with ease, seem to render this ophthalmoscope both *complete* and *convenient,* on account of which I feel encouraged to bring it to the notice of the profession.

ON THE DERANGEMENTS OF MOTION FOLLOWING DIVISION OF THE SEMICIRCULAR CANALS.

By Dr. LOEWENBERG, Paris.

(Translated by Clarence J. Blake, M.D., Boston.)

One of the most curious facts educed by Flourens from his beautiful experiments on derangements of motion in animals is unquestionably that concerning the remarkable movements of the head, as well as of the rest of the body, in animals in whom the semicircular canals had been divided. Having been occupied for many years in the special study of the ear in health as well as in disease, I could not but take the greatest interest in these remarkable phenomena, and determined to undertake a further investigation of this interesting subject, the more so that I believed myself to have found some points of vantage which would lead to a nearer understanding of the mechanism of these symptoms. Instead, therefore, of simply repeating the experiments of Flourens as it had been heretofore done, it appeared possible, by a modification of the circumstances under which the division of the semicircular canals in animals was performed, to obtain further information concerning the conditions necessary to the occurrence of the phenomena. I hoped, for instance, to determine by experiment the question as to whether the movements

of the animal operated upon were really caused by pain, as Flourens believed, and whether, as a rule, consciousness was necessary to the occurrence of the derangements of motion.

The following pages will show how far my hopes were realized, and in what degree I have succeeded in contributing to an understanding of the nature of these mysterious facts. In regard to the curious movements which follow division of the semicircular canals, I would refer to the excellent description in Flourens's work (FLOURENS, *Recherches Expérimentales sur les Propriétés et les Fonctions du Système nerveux. Seconde édition*, page 454, iii.—460, VI.). The symptoms which I have observed in numberless experiments on division of the semicircular canals agree so fully with those portrayed in the work above cited, that I consider any further description of that which has been so often described as wholly superfluous, and will content myself with a concise statement of whatever may be worthy of mention that I have educed therefrom. In the first place, careful dissections of all the animals upon which I have operated have shown, contrary to the views of certain physiologists, that accidental injury of portions of the brain cannot be considered as constituting a cause of these remarkable phenomena.

Such injury accompanying division of the horizontal and small vertical canals is, moreover, entirely out of the question. This is not the case, however, according to my experience with the large (superior) vertical canal. The inner wall of this canal projects so far into the cranial cavity that it is impossible to effect complete

destruction of the canal without lesion of the cerebellum.

My experiments, furthermore, gave a result in opposition to the statement of Professor Czermak. According to his opinion, vomiting is a constant sequence of injury of the semicircular canals. On the contrary, in the large number of experiments which I instituted, this symptom was observed in but one case, following the operation upon a pigeon. As is shown, however, in the following record of the experiment in this case, an undue depth of the incision injured the cerebellum, and upon dissection an extravasation was found in this organ. The vomiting, therefore, was not the result of the injury to the canals, but of the inroad upon the cerebellum, and it appears very probable to me that a similar injury interfered with the experiments of Professor Czermak.

Experiment No. 1, *July* 11, 1869.—The left horizontal semicircular canal of a pigeon was divided on both sides of the vertical canal. The bird ran quietly about the room, and on being thrown down from the table immediately got upon its legs again. Fifteen minutes later, by means of a deep incision, the right horizontal semicircular canal was divided outwards from the vertical canal. Movements of the head from right to left immediately occurred, together with rotatory movements of the body in the same direction. The pigeon repeatedly fell suddenly to the ground; in a few moments there was a single attack of vomiting, and the movements continued.

July 14.—Continuance of the symptoms, but increased

in severity. The pigeon held the head firmly pressed upon the ground, in such position that the occiput rested upon the floor and the eyes were directed upwards. The movements consisted in rotation upon the long axis, and also upon the transverse axis (somerset), and, in addition, exceedingly complicated movements, the head being continually twisted from left to right (the right eye turning towards the left side); if the head was forced into its natural position, it immediately resumed the abnormal position so soon as it was released. (During sleep, and even sometimes while awake, the position of the head was normal!)

Death occurred on July 27th, at noon. The dissection, which was made on the 29th, showed extravasated blood to the right and left of the canals, the middle lobe of the cerepellum hyberæmic, the capillaries especially being filled with blood. Examined with the naked eye, this portion showed a peculiar greenish-yellow color. The osseous as well as the membranous canals were divided, and there was no trace of reunion. On the right side the incision had slightly entrenched upon the vestibule.

In proceeding to repeat the experiments of Flourens, I had in mind to investigate whether any conclusions could be arrived at concerning the nature of the cause of these disturbances. No one has as yet considered, for instance, the point as to whether the symptoms in question have their cause in an *irritation* or in a *paralysis* of the nerves, but it is primarily evident that this question must first be answered before a clear insight into the circumstances under considera-

tion can be obtained. I purposed, therefore, experimenting upon the effects of irritating these canals. The choice of irritants applicable to this purpose was very limited. The use of electricity presented the greatest difficulties, as it was impossible to fix the animal sufficiently for the purpose of observing the result of the irritation; similar objections precluded the use of mechanical means of irritation, as it is very difficult, during the observation of the disturbances of motion, to continue the application of the irritant. I concluded, therefore, to limit myself to the use of chemical irritants, and selected for this purpose common salt, in crystals or in saturated solution. The following experiment, selected from a number performed in the same manner, exhibits the result arrived at:

Experiment No. 2, *July* 17, 1869.—The small vertical canal on the right side in a pigeon was crushed with the forceps so that a portion of the membranous canal was visible. There immediately followed rotation of the head towards the right side, and falling towards the right on movement. A small piece of salt being placed upon the membranous canal, there was no change in the symptoms, but on application of a concentrated solution the bird showed an inclination to press the right side of the head against the wall, and the movements for some little time were more violent than before.

That we have here to deal with the phenomena of *irritation* appears to me unquestionably deducible from the fact that in all cases the application of a concentrated solution of salt is accompanied by an increase in vehe-

mence of the movements; in this connection the circumstance that the bird pressed the head forcibly against the wall, as if for the purpose of removing the cause of pain, is characteristic. These and analogous experiments appear to me, therefore, to prove that *the disturbances of motion consequent on division of the semicircular canals originate in an irritation of the membranous canals.*

We have further to inquire as to the nature of these disturbances of motion resulting from the irritation of peripheral structures. Have we to deal with simple reflex movements, or are the remarkable contortions of the animals operated upon the expression of a pain actually felt, and therefore consciously perceived? This question could be determined only by experiment, and there was but one means open for its solution, namely, the elimination of that organ upon the integrity of which the preservation of consciousness depends—the cerebrum. There were two methods of accomplishing this:

1. Simple extirpation of the cerebral hemispheres (easily performed in pigeons).

2. Anæsthetization of the animal experimented upon.

1. I cite a few experiments in which I endeavored to accomplish the object by the first of the measures above mentioned.

Experiment No. 3.—The cerebral hemispheres were wholly removed from a pigeon, the bird remaining quiet. Several of the semicircular canals on both sides were then divided; the characteristic movements immediately appeared and continued with great vehemence. Five

or six minutes later I removed nearly the entire upper half of the cerebellum. The movements continued with undiminished violence; possibly they were somewhat more complicated than before (?). The symptoms continued the same. On division of the spinal cord, the abnormal movements immediately ceased. (The reflex movements, however, continued.)

Experiment No. 4.—Several of the semicircular canals were divided on both sides in a pigeon. The characteristic symptoms immediately appeared. The cerebral hemispheres were then removed: the movements continued a few minutes and then subsided. The bird remained motionless, but so soon as it was touched or pushed the derangements of motion consequent on the division of the semicircular canals reappeared and continued for several minutes.

Experiment No. 5.—Several of the canals were divided on both sides in a pigeon, with the occurrence of considerable hemorrhage. The characteristic movements appeared as usual, and continued several hours after the removal of the cerebral hemispheres. On the following day the bird was quiet. The movements appeared immediately, however, when the pigeon was touched or pushed.

On examining these experiments more precisely, we find them to show first of all that the removal of the cerebral hemispheres exerts no influence on the occurrence of the derangements of motion, neither does their previous removal prevent the occurrence of the symptoms following division of the semicircular canals, nor are these symptoms resulting from division of the

canals thereby arrested. Removal of or injury to the cerebellum has also no influence on the occurrence of the movements, inasmuch as they can neither be made to cease nor can their occurrence be prevented by this means. Injury to the cerebellum, on the other hand, renders the movements still more complicated, as it adds to the symptoms consequent upon irritation of the semicircular canals those resulting from injury of the cerebellum.

In this connection Experiment No. 8, in which the combined movements first appeared when an injury to the cerebellum was added to that of the canals, is of interest.

These experiments on pigeons from which the brain has been removed exhibit the peculiarity that in such cases the derangements of motion persist but for a short period and then cease, to be renewed, however, on striking or shaking the bird. In Experiment No. 5 only, in which the division of the canals was accompanied by a considerable hemorrhage, did the movements continue for a couple of hours after the removal of the cerebrum. On the following day, however, the bird was in the same condition as that of other pigeons from which the brain had been removed. This peculiar phenomenon is most important, and contains the key to the knowledge of the true nature of these derangements of motion. We will therefore consider this point at greater length hereafter.

2. We will now consider the experiments in which the birds were chloroformed.

Experiment No. 6.—A small sponge saturated with

chloroform was held to the beak of a pigeon for a few moments. The bird dropped its head and remained quiet. The loudest noises caused no change of position. The horizontal canal and one vertical canal on the left side were then divided. Some movements of the head from left to right immediately occurred.

The corresponding canals on the right side were then divided, the result being violent movements of the head from right to left, and *vice versâ*, accompanied by falling, and an impossibility to maintain the equilibrium. About half a minute later the pigeon remained quietly standing, the movements of the head having also ceased. On striking or shaking the bird the movements reappeared, to disappear in a few moments. Ten or fifteen minutes later the bird made a voluntary attempt to move from its position, when the characteristic movements immediately reappeared, with even greater intensity than when under the influence of the anæsthetic. The bird finally regained consciousness, and endeavored to escape by flying. The remainder of the experiments completed under chloroform gave precisely similar results: the movements appeared immediately after the operation, disappeared at the end of a few moments, only to reappear when the bird was struck or shaken. So soon as it awakened from the narcosis the characteristic movements began. (In these experiments only minimum doses of chloroform should be used, as the pigeons are easily killed thereby.)

The results of these experiments, on the whole, are entirely in accord with those obtained in pigeons from which the cerebral hemispheres were removed.

In both series of experiments the derangements of motion appear immediately after the operation, and soon subside, to be reproduced only by a change in the position of the bird. The observation made upon pigeons from which the brain was removed, that when the division of the semicircular canals was accompanied by considerable hemorrhage the movements continued for a long time, from half an hour to an hour after the operation, and ceased only at the expiration of this period, is equally applicable to the experiments under anæsthetics. Precisely similar symptoms were observed during sleep in pigeons in which the semicircular canals had been divided; the movements ceased entirely, but recurred so soon as the bird was awakened by a noise.

It is now proper to seek for the interpretation of these two groups of experiments made upon birds deprived of consciousness. There is no difficulty in doing this, if we take into consideration the following points:

1. The derangements of motion resulting from division of the semicircular canals occur even when the birds are in conditions in which they neither perceive pain nor are capable of voluntary movement. It follows necessarily that the derangements of motion are of *reflex origin*, and furthermore, in reference to the explanations above given, that they are a consequence *of irritation of the membranous semicircular canals.*

2. Upon division of the semicircular canals of animals which are unconscious, the resultant movements possess the peculiarity of continuing but a short time after the operation, and, when they have once ceased, of being recalled only by moving or shaking the animal.

This fact proves that in animals operated upon under these circumstances the irritation is not a continuous one, and recurs only on movement.

The manner in which movement causes renewed irritation is readily comprehensible: the most insignificant hemorrhage, the slightest mechanical shock, even mere contact with air of a different temperature, is sufficient to excite intensely an organ so exceedingly sensitive as the membranous semicircular canals. Of the accuracy of this explanation there is evidence in the fact—

3. That even in animals in a state of unconsciousness the derangements of motion continued for a long time in cases wherein the division of the canals was accompanied by severe hemorrhage.

We may now introduce the question as to why it is that these reflex movements are continuous in normal animals, but on the other hand discontinuous in animals which are unconscious.

At the first glance this phenomenon appears to stand at variance with the well-known fact that reflex movements in animals which have been deprived of consciousness are usually more violent than in animals in the normal condition. This contradiction is, however, only an apparent one. We have seen (*sub* 2) that the discontinuance of the movements following division of the semicircular canals is merely a result of the discontinuance of the irritation, which is always reproduced by a movement of the animal.

Birds with the cerebrum intact, however, make continual attempts at flight, and it is these movements which keep up a continuous irritation.

In animals deprived of the function of the cerebrum, the intensity of the derangements of motion is only *apparently* less than in animals under comparatively normal conditions, and this appearance rests simply on the fact that in the first case the irritation which calls for the reflex movements persists but for a short time. If the irritation is present, the derangements of motion in the latter case, if not more violent, are at least as violent as in pigeons in which the brain is intact.

It is also not impossible that the flying movements which the bird, whose cerebrum is uninjured, makes after the division of the semicircular canals, are partially due to the pain resulting from the operation; and yet, even if this were possible, it would not in the least follow that Flourens was correct in attributing to pain alone the derangements of motion following division of the semicircular canals. The difference between the results of my experiments and the conclusions drawn by Flourens is very great. According to my experiments these movements are of a purely reflective nature, and occur without the presence of consciousness. When consciousness or the appreciation of pain co-operate in the production of these movements, it is only indirectly by exciting the bird to voluntary attempts at flight, and thus affording a cause for the origin of the reflective irritation. According to Flourens, on the contrary, the appreciation of pain is the direct origin of the derangements of motion, and according to his view the bird makes the characteristic movements of the head for the purpose of removing the cause of the pain. But one objection, so far as I am aware, can be raised to the

conclusion deduced from my experiments, and that is as follows: "If each movement of the animal operated upon," it might be said, "causes irritation of the membranous canals, the derangements of motion in pigeons from which the brain has been removed should also be continuous, because, if the bird has once made the abnormal movements in consequence of irritation of the canals, these as well as every other movement must induce further irritation, which would call forth a repetition of the derangements of motion, these producing further irritation of the semicircular canals, etc." The force of this apparently important objection is, however, diminished by the following consideration. The violent convulsive movements made by the bird induce exhaustion both of the motor nerves and of the muscles, and also of the sensitive portions of the membranous canals. Rightly considered, these movements do not continue undiminished in animals with normal brains. In these cases pauses of some minutes occur, during which the animals are quiet as the result of exhaustion. The difference between normal pigeons and those from which the brain has been removed is merely this, that the former, so soon as they have rested, commence making voluntary movements which induce irritation of the membranous canals, while the latter, when once brought to a condition of quiet by exhaustion, remain in that condition until some external impulse again sets them in motion. In a word, exhaustion breaks the chain of phenomena which was implied in the objection just urged.

My experiments having convinced me that the de-

rangements of motion following division of the semicircular canals of the labyrinth were of reflex character, the next point was to determine the *place of transmission of this reflex.* Before directing my experiments to the spinal cord, it was necessary to examine as to whether the transmission might not take place in some portion of the brain which had been left intact in former experiments, namely, in that portion designated as the thalamus.

Experiment No. 7. *Aug.* 5, 1869.—The cerebral hemispheres were entirely removed from a pigeon of medium size. On subsequent division of some of the canals on the right side, the bird made a few movements of the head. The canals of the left side were then divided, followed by violent movements of the head and rotatory movements of the body (the head being carried towards the left). I then removed the cerebellum; the movements continued for a short time in diminished intensity, and finally manifested themselves only by slight movements of the head. Upon placing the pigeon on the ground the rotatory movements recommenced in the same direction as before; the head was pressed with the occiput against the ground. Upon removal of the thalami optici, the head rested quietly upon the ground, and the bird died.

Experiment No. 8. *Aug.* 5, 1869.—The cerebellum was mutilated in a pigeon. Rotatory movements backwards and towards the left followed. The canals on the right side were then divided, when there occurred violent movements of the head and the body of a complicated character. These were not "mouvements de

manège," but a reeling from right to left. The canals on the left side were then divided. The movements remained the same in character, but the excursions were greater. The pigeon dashed the head forcibly towards the right (previously towards the left). The cerebral hemispheres were then removed. The movements continued. I then removed the remainder of the cerebral substance and the thalami. The movements ceased and the bird remained alive.

Experiment No. 9. *Aug.* 12, 1869.—I removed the right cerebral hemisphere and the right thalamus from a pigeon. Immediately thereafter the bird twisted the head downwards, so that the beak was directed upwards. In so doing the head was twisted from left to right. The bird then turned violent somersets backwards, at the same time falling towards the right side. Shortly after the movements of the head ceased. I then divided the external vertical canal on the right side. The pigeon immediately shook the head from right to left; the body was supported upon the tail and rotated from left to right. The pigeon fell towards the right. I then removed the left cerebral hemisphere and the left thalamus: the movements immediately ceased entirely. Division of the left external vertical canals did not cause them to recur.

These experiments show that removal of the thalamus is followed by immediate cessation of the movements even in those cases in which the birds survived the operation for some time. (See Experiment No. 8.)

The ninth experiment shows, furthermore, that the removal of one hemisphere and one thalamus presents

no hindrance to the occurrence of the symptoms, but that the latter cease only so soon as the thalamus of the remaining side is removed. We cannot, of course, attach any importance to the movements which occurred after simple removal of one hemisphere and one thalamus. In these experiments the circumstance that, following division of one of the right vertical canals (therefore only unilateral injury to the semicircular canals), violent and continued movements occurred, and further that these were, not as is usual from the wounded to the normal side, but in a contrary direction, is particularly remarkable and difficult of explanation.

It is proved, therefore, by the above experiments, that the transmission of the irritation from the sensitive portions of the semicircular canals to the motor nerves which take part in the production of the derangements of motion, occurs in the thalamus. This result naturally obviated the necessity of proceeding to experimental division of the spinal cord. The results of experiment No. 9 are difficult of explanation. Is it possible that a portion of the nerve-fibres coming from the canals intersect in the thalamus?

Condensing the results of my experiments on pigeons, I believe that I have proved the following points:

1. That the derangements of motion following division of the semicircular canals are the result of this injury, and not of an accompanying injury to portions of the brain.

2. That the vomiting observed by Professor Czermak

in his experiments was the result of an accompanying injury of the cerebellum.

3. That the derangements of motion are the result of irritation of the membranous canals, and not of paralysis.

4. That the irritation of the semicircular canals produces the convulsive movements *reflectively*, without participation of consciousness. Consciousness participates in these effects only in so far as it gives rise to renewed irritation, by inciting the animal to voluntary movement.

5. The communication of this reflex excitation from the nerves of the membranous semicircular canals to the motor nerves takes place in the thalamus.

Appendix.—Experiments on Rabbits.

According to a well-known observation of Dr. Brown-Séquard, division of the nervus acusticus induces the same derangements of motion as lesion of the semicircular canals. In this connection I have instituted a series of experiments on rabbits, which I will briefly describe, and of which the following experiment serves as an example:

Experiment No. 10.—The nervus acusticus in a rabbit was divided from the tympanum. (See the method described by Claude Bernard for division of the facialis, in his *Leçons sur la Physiologie et la Pathologie du Système nerveux.* Tome ii., 18 et 19.) For this pur-

pose the knife was carried into the tympanum forwards and upwards. There immediately followed the characteristic movements of the head from right to left, and, in addition, the "mouvements de manège." The right ear seemed to have lost its hearing power. The "mouvements de manège" continued for several days, but diminished in intensity during sleep. If the animal was shaken or struck, they increased in violence. On the third day the animal was killed. The dissection showed that while the right auditory nerve was almost completely divided, at the same time the semicircular canals of this side were partly crushed and partly broken in. Other experiments gave precisely the same result. In all cases the canals shared in the injury. A division of the nervus acusticus, therefore, without accompanying injury to the semicircular canals, cannot be accomplished (at least by this method).

In these experiments the constant occurrence of the "mouvements de manège" without injury (as was shown on dissection) to any portion of the brain was remarkable, and furthermore, the occurrence of continuous derangements of motion accompanying only unilateral injury of the canals. Vomiting was not observed in any of these experiments.

Remark.—The preceding paper, written in French, was sent, competing for a prize, to the *Académie des Sciences, in Paris*, on June 6th, 1870. External circumstances prevented the author from publishing it earlier, and from availing himself of later researches, especially those of Prof. Goltz. The preceding investigations, starting from new points of view, yielded results which are, perhaps, not unworthy of the notice of the profession.

THE AUTHOR.

EMBOLISM OF THE CENTRAL ARTERY OF THE RETINA.

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(Translated by Dr. Hasket Derby, Boston.)

A case of blindness occurring in connection with the chain of symptoms which characterize embolism of the central artery of the retina, is still entitled to be regarded with more interest than a single observation in most instances is capable to elicit. For the hope expressed by Virchow,* in closing his classical researches on thrombosis and embolism, that—"if a chance should be offered of making an ophthalmoscopic examination in cases of very recent embolism of the larger retinal arteries, it might be possible, during life, to distinguish the occluded portions by their whiteness and trace directly the progress of secondary derangements, all of which would have a most valuable bearing on the theory of metastasis"—this hope has been only partially realized. It is true that we are at present in possession of a satisfactory though not very large number of observations in which the diagnosis of obstruction of retinal vessels by embolism is well made out, though unsupported by anatomical proof.† It is true that Knapp has

* Gesammelte Abhandlungen, p. 723.

† Cf. Stellwag v. Carion, Lehrbuch der Augenheilkunde, 1867, p. 791. Roth, Ueber Netzhautaffectionen bei Wundfieber. Deutsche Zeitschrift f. Chirurgie, Bd. I. Heft 5, p. 471.

recently described* a hemorrhagic infarctus as the keystone, so to speak, to the picture of derangements in the circulation of the retina caused by embolism; but the analysis and the history of all these observations are, in many respects, so varying and even contradictory, both in the apparently similar mechanical conditions and in the consecutive, nutritive and functional derangements, that a general description of the disease under consideration can only be given with the utmost caution, and a diagrammatical explanation of the secondary derangements, or an elucidation of the process of metastasis, has, from this part at least, hitherto been out of the question.† It is only since Cohnheim's‡ recent luminous investigations have cleared up the subject of mechanical derangements of the circulation succeeding arterial embolism, and especially since the vague conception of collateral fluxion has been reduced to its proper proportions, that it will perhaps be possible to marshal the numerous variations of the observations on record, in obedience to an ordered system, to subject the published cases to a more rigid criticism, and to find a surer foundation for diagnosis.

Before, however, I discuss previous observations with reference to the results gained by the experiments of Cohnheim, I would crave permission to report an original observation, which excited me all the more to this investigation by its coincidence with the appearance of Cohnheim's work.

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* Archives of Ophthalmology and Otology, Vol. I., 1, 1869, 64–84.

† Steffan, Ueber Embolische Retinalveränderungen, Graefe's Archiv, XII., 1., p. 42.

‡ Cohnheim. Untersuchungen über die embolischen Processe, 1872.

Maria P., a woman of no especial vigor, 62 years of age, came to me, August 2d of this year, complaining that fourteen days ago, after passing a quiet night, she remarked in the morning entire blindness of the left eye, although she was perfectly certain of having seen well with it the evening before. On awaking, she had a feeling as though this eye were shut, and consequently asked her husband to take a look and ascertain why she could not open it.* Being informed by him that it was open, she experimented on the acuteness of vision of each eye, and found that with the left she could not even distinguish light from darkness. She at once consulted an oculist, who told her there was nothing to be done for the eye, that it was lost. Alarmed at this opinion, she went to another, who ordered her iodide of iron, but said nothing about her condition; and it was at the end of fourteen days that she came to me to obtain my opinion concerning the disease.

The objective examination showed the following:

The *right* eye, emmetropic, has S = 1, and the amount of accommodation corresponding to the age of the patient. In spite of the normal acuteness of vision the patient insists that all objects seem *smaller* to her than formerly. As no comparison with the appreciation of magnitude by the left eye could be made, I was unable to estimate at its proper value the correctness of her statement. This seeing things smaller, however, inspired her with much apprehension for the future. Ophthalmoscopic appearances normal.

In the left eye there is a dull quantitative perception of light in the eccentric portion of the field lying upwards and inwards; a large lamp being distinguished when held close before the eye, while in the central and remaining portions of the field entire blindness prevails. The cornea and iris are unaltered; the pupil is

* Steffan's patient experienced the same feeling. L. c., p. 36.

moderately enlarged, as in cases of paralysis of the oculomotorius, and reacts with extreme sluggishness when exposed to light; still, this reaction is independent of the movements of the other iris, and is incontestably present. The intra-ocular pressure is perceptibly heightened, albeit to no great extent.

Ophthalmoscopic Examination. — The transparent media are entirely clear, the refraction of the eye emmetropic. On bringing the fundus into focus the attention is at once arrested by the threadlike appearance of the retinal vessels, it being at first sight impossible to distinguish between the arteries and the veins, the reflex due to the tubular form of the arteries being wholly wanting. On closer examination it is seen that the papilla has clean-cut edges, *is surrounded by no retinal cloudiness*, and is tolerably pale, but still by no means exhibits the dazzling whiteness of atrophy. The paleness here described is all the more marked by the sharp contrast it offers to the *normal redness of the fundus.* The veins emerge with narrowed channel from the vascular centre of the papilla, and gradually increase in diameter as they approach the periphery, but even at the equator attain to scarcely half the thickness of the veins seen in the other eye. They convey blood throughout their whole course, and exhibit no portions free from blood with oscillating movements. The arteries depart from the point of entrance of the vessels as thin, bright-red threads, and become in part brighter, but less visible, as soon as they pass beyond the edge of the papilla, owing to the lessened contrast between them and the red fundus oculi. One artery proceeds,

in the inverted image, downwards and inwards, is accompanied for a certain distance by a vessel readily made out to be a vein, and gives forth a dark-colored, spindle-shaped swelling, starting off from the thread-like vessel at a distance of about one and a half diameters of the papilla from the edge of the optic disk; just behind this enlargement the vascular canal entirely escapes recognition. The most rigid investigation in the upright image fails to detect any oscillating movement in the contents of this vessel. The vein corresponding to this arterial division is the fullest of any of the fundus, and tapers but slightly as it approaches the point of entrance of the vessels. The whole extent of the macula lutea has a bloody tinge, is not surrounded by any whitish opacity, does not look like the seat of an extravasation, but, on the contrary, seems, in spite of its redness, to preserve a uniform granular appearance, and keeps its normal line of demarcation from the vicinity (it being remembered that the boundaries, at an age like that of the patient, are not particularly marked or circumscribed); it is, however, remarkable that the vessels, so thin throughout the remainder of the fundus, assume such prominence in the region of the macula. The strongest pressure on the eyeball excites no arterial pulsation; the phosphenes are perfect.

Of the significance of the ophthalmoscopic symptoms there could be no question. The sudden advent of blindness, the striking diminution in size of the vessels, especially of the arteries, the enlargement of the veins towards the periphery, the impossibility of exciting arterial pulsation by pressure, all pointed to a cutting off of

the arterial circulation. In what portion of its course the principal artery was obstructed could hardly be ascertained after a lapse of fourteen days, inasmuch as collateral circulation had probably been set up. It appeared, however, certain that the occluding clot could not be in the ophthalmic artery, inasmuch as the choroidal circulation was not only unimpaired, but seemed even more vivid than in the other eye, to judge from the existing increase of intra-ocular pressure. As has been stated, a spindle-shaped swelling could be made out in one artery, on either side of which the vessel was extremely narrowed. The whole region gave the impression that we had here to do with a small embolus, which had obstructed a single branch of the central artery. This observation agrees entirely with that of Cohnheim, according to which *the channel of the vessel is more or less dilated at the point of obstruction, but appears decidedly contracted both in front of and behind it.**

The second and principal embolus must, of course, be situated in the trunk of the *arteria centralis retinæ*, at what point will be discussed further on. The source of the embolus was the next question. The most thorough examination of the heart and the large vessels revealed nothing in the least abnormal to either percussion or auscultation; the radial arteries, however, especially the left, showed hard atheromatous deposits in the middle coat, yielding to the finger the familiar sensation of a bird's trachea. Inasmuch as an atheromatous condition of the cerebral arteries is frequently present with-

* Loc. cit., p. 11.

out any manifestation of atheroma in the remaining arteries of the body, while conversely atheroma of the arteries of the body seldom fails to implicate those of the brain, it became necessary to assume some process within the internal carotid or ophthalmic arteries, from which diseased vascular region the current of the circulation swept particles of tissue or thrombic clots into the central artery and one of its branches.* The inducement to believe in some such disease of the cerebral vessels and the consequent derangement of nutrition of the organ itself became all the greater when it was considered that the woman had previously been both cheerful and lively, but of late had grown melancholy, lachrymose, and had come to be haunted by impressions of impending misfortune; the veins of the face, moreover, exhibited unmistakable symptoms of stagnation of the circulation. Urine normal. I venture only to hint at the possibility of a connection between the micropsia of the right eye and the above-described derangement of nutrition.† The following points bore on the question of therapeutics:

1. The mobility of the pupil when exposed to light, and the perception of light, slight though it was, in a limited portion of the visual field;

2. Phosphenes responding to pressure;

3. Absence of any striking alteration of tissue in the retina;

4. Absence of any cardiac disease.

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* Cf. Steffan, loc. cit., p. 39. Liebreich, Deutsche Klinik, 1861, No. 50, p. 476.

† Cf. Panum. The apparent Size of Visible Objects. Graefe's Archiv, Bd. V., 1, p. 16.

The slight but still uniform and equal fulness of the arteries and veins giving good grounds for belief that the collateral circulation proceeded from the ciliary vascular plexus, the first indication seemed to be, by stimulating this, to cause an afflux of blood towards the retina that should not only prove a source of nutrition to its tissue, but also enable it to resume its functions. For thus must we theorize with regard to the apparently singular fact that a failure of nutritive supply may not cause the destruction of a tissue, while leading to a limitation or entire suspension of its functions; the collateral circulation following directly on the obstruction being sufficient to prevent the necrosis of retinal tissue, but unequal to the task of maintaining an exercise of functions that are necessarily accompanied by a large consumption of material; a view of the case amply justified by analogy in other organs. This view, too, harmonizes very well with the fact of the good preservation of the phosphenes. For inasmuch as the *larger* retinal arteries ramify in the inner, *conducting*, layers of the retina, irritation of which originates the phosphenes, these layers, though their vessels be but partially filled, must retain a certain limited activity beyond that enjoyed by the external, *perceptive*, retinal layers, which are permeated only by the finer subdivisions of the central artery, and must hence remain more empty when the circulation is impeded.*

* Cf. Steffan, l. c., p. 62, whose view of the *exclusive* supply of the external retinal layers by the chorio-capillaris is hardly tenable. I would simply refer, in this connection, to the preservation of the functions of a retina overlying choroidal ruptures, etc.; Knapp, Archives of Ophthalmology and Otology, I., 1., p. 169.

The question, of course, arose whether a stimulation of the retinal circulation, provided we could bring this about, might not drive the embolus still deeper into the central artery, and thus gravely compromise the collateral circulation, so recently established. This doubt, upon which the treatment of Schneller's* single successful case was based, appeared to have no bearing on the present one. In the first place, the embolus having remained fourteen days in one place, which it entirely filled, could hardly be assumed to be sufficiently movable to yield before the *dash* of the blood; in the second place, we had a right to argue that the current would follow, by preference, the already open channels of the collateral circulation, a thing proved by experiment, inasmuch as clots generally extend to the *next higher* anastomosis.

Among the means of bringing about an increase of force in the circulation towards the retina, iridectomy occupied the first rank, an additional inducement to its performance being the indubitable increase of intra-ocular pressure. This increase of intra-ocular pressure is a phenomenon both significant and interesting; significant in regard to its results, which impeded the rapid accomplishment of a collateral circulation; interesting with reference to its development, which allows us an insight into the peculiar derangements of circulation that accompany retinal embolism. These derangements of circulation in an eyeball closed on all sides, and provided with two nearly independent vascular systems,

* Graefe's Archiv, VIII., 1, p. 274.

must run a course very different to that observed in the tongue of the frog, the object studied by Cohnheim. In this latter case the single requisite for the formation of a collateral circulation is the presence of anastomoses, and the tissue interposes no obstacle to the re-establishment of a vascular current, while in the former the greater or less rigidity of the sclero-corneal capsule, the tension of which is maintained by the vitreous, offers a very appreciable resistance. The normal retinal circulation is an indubitable adjunct to the amount of the intra-ocular pressure, through the quantity of blood contained in the retinal vessels; still it is now beyond disputation that the choroid and ciliary body are the real source of the fluids that create the intra-ocular pressure. When now an embolic closure eliminates the retinal circulation, how is the intra-ocular pressure affected? At the very first it will undoubtedly decrease in direct proportion to the amount of blood circulating in the retina; this decrease, however, is partially neutralized, and finally reduced to a minimum by the elastic contraction of the envelope of the globe. The situation, however, almost immediately changes. The obstruction of the central artery drives the blood into one or several of the preceding lateral branches of the ophthalmic, and causes it to flow with increased rapidity into these, *i.e.*, the ciliary arteries; "with the same increased rapidity the blood traverses the capillaries supplied by the said lateral branches, and runs all the more quickly into the veins that carry it off. This acceleration of the circulation in these arteries, capillaries, and veins remains for a longer or shorter time at the same height,

without causing a rupture and hemorrhage, until finally a gradual and equable distribution of the superfluous current is made over several of the preceding neighboring branches, and an equilibrium thus established." *

I have almost literally transcribed this passage from Cohnheim's article, because this observation, based on experiment, seems to me to furnish the key to a proper conception of the mechanical conditions that ensue on vascular obstruction due to embolism. At a later period we shall more clearly perceive the neglect that has been bestowed on, and the faulty conclusions that have been derived from, this state of things. If these experimental results be applied to the present case, it will be seen that the circulation will be affected as follows: The blood will flow with increased rapidity through the ciliary arteries to the chorio-capillaris and ciliary veins; the process of filtration is thus hastened and the intra-ocular pressure increased; this temporary increase of the inner pressure of the eye hinders again the quick completion of the collateral junction in the region of the optic papilla, and the blood hence rushes with a constantly growing rapidity into the posteriorly situated ciliary arteries. As the intra-ocular pressure increases, the activity of the increased rapidity is converted into an increased lateral pressure, and the filtration pressure of the chorio-capillaris thus increased, so that as a final result of the dilemma we note an increase in the intra-ocular pressure and an impeded current in the direction of the collateral optic vessels, and this in spite of the

* Cohnheim, l. c., p. 9.

vascular distribution at the extremity of the optic nerve that seems so favorable to the quick development of a collateral circulation.

Guided by this reasoning, I decided at once to perform iridectomy, the influence of which to diminish pressure in a similar case had already been tested by v. Graefe.* On the very next day I made a broad coloboma upwards, and took pains to let the aqueous humor escape somewhat rapidly. The day following I could not refrain from a cautious examination of the vision and the fundus, the absence of all reaction rendering this apparently devoid of danger. There could be no doubt of an increased perception of light, extending over a large portion of the visual field; it was, however, in no degree qualitative. Ophthalmoscopic examination revealed a considerable alteration in the state of the vessels; the arteries were much fuller, and distinguishable from the veins by their color as well as by a certain reflex, this distinction being most marked in the arterial branch containing the swelling that has been characterized as an embolus. The central contraction in calibre of the vessel had now disappeared, and with it the spindle-shaped enlargement, but it was, as before, impossible to trace the vessel at its peripheric continuation beyond the embolus. The latter, however, had not changed its position. The result of the following and more comprehensive examination, which was made three days after the operation, was the astounding fact that the patient could count fingers with tolerable cor-

* Cf. Graefe's Archiv, V. 1, p. 151. Knapp, Ueber Verstopfung der Blutgefässe des Auges, Graefe's Archiv, XIV., 1, p. 219.

rectness, not, it is true, centrally, but with a portion of the retina closely bordering on the centre; only below and inwards no trace of a perception of light had returned, corresponding entirely to the spindle-shaped swelling which lay in the inverted image, below and inwards. Ophthalmoscopic appearances the same as two days before. During the next few days the improvement somewhat progressed; large objects like a watch, key, knife, etc., being made out, and the power of vision gradually approached the centre. A change, too, in the ophthalmoscopic appearance of the macula lutea could now be observed. The blood-red color gradually disappeared from without inwards (inverted image), and gave way to a brownish yellow, without, however, the development of any opacity at this point. I must advert here to one very strange symptom. While the patient, in a darkened room, had an accurate perception of fingers and other objects gently illuminated by a gas-jet at her side, except over that portion of the visual field that has been already repeatedly alluded to, she was yet unable to recognize or state the position of the full jet of gas when carried directly before her eyes. A curious analogy exists between this and cutaneous analgesia, and has been already several times adverted to in cases of amblyopia following a large loss of blood.* It seems to me more an evasion than an explanation of this phenomenon, to say that the retina, long disabled functionally, responds to a slight, but is exhausted by a strong, stimulus, and I simply here note

* Vikentscher, Graefe's Archiv, VIII., 1, p. 213. Colsman, Klinische Monatsbl., VII., p. 13.

the fact. Not till ten days after the operation did this symptom disappear and the patient accurately localize the largest flame.

I expected now that the improvement in the power of vision would steadily progress. My hope was, however, disappointed, and soon gave way to the fear that what had already been gained might yet be lost. In this apprehension I was by no means guided by the perception of light, which persisted over the whole surface described, but by the ophthalmoscopic appearance of the retinal vessels; for these began again to exhibit a diminished calibre, especially the branch with the embolus, which latter clearly displayed again a spindle-shaped swelling, on either side of which the vessel was contracted, just as before the operation. It was clear that the diminution of intra-ocular pressure, due to the operation, had begun to lose ground, and that the process of cicatrization was offering a fresh obstacle to the collateral circulation that had been excited.

Under these circumstances the patient was dismissed from the hospital, but has remained under surveillance up to the present time. The ophthalmoscope reveals now the last-described state of things, the vessels being moderately contracted, the spindle-shaped swelling present, the veins less attenuated at their point of emergence, and the macula lutea yellowish brown. The white discoloration of the papilla has not increased, and neither has any alteration in the visual power of the left eye taken place since the examination last described. Nor is the right eye at all changed, and, according to the patient's account, the micropsia remains the same.

I cannot, at present, find any reason for this either in the accommodation or the retina.

On reviewing now the single elements which went to make up the diagnosis of our case, we are struck first of all with the absence of that loss of transparency of the tissue which, with hardly an exception, has characterized every case of embolism of the central artery that has hitherto been described. The objection might indeed hold that this was present during the days that first elapsed after the formation of the embolus, and had already disappeared without leaving a trace behind, when I made my first observation, fourteen days after the advent of blindness. A glance at the best known of the hitherto published cases will most quickly inform us with reference to the admissibility of such a theory.

The table opposite shows that the commencement of opacity of the tissue is ordinarily noted during the days that immediately succeed the embolic obstruction, and that, while the opacity in many cases takes more than fourteen days to disappear, shorter periods are not uncommon. Under these circumstances we are not called upon to decide on the absence of opacity in our case, and are at liberty to rank it with Schneller's, which he observed the twelfth day after blindness occurred, and noted *no opacity of the tissue whatever.* These two observations, however, open the discussion as to whether the early or late occurrence of opacity of the tissues is a necessary consequence of the embolic occlusion of the central artery.

TABLE I.

No.	Name of observer.	Situation and extent of the opacity.	Day it appeared after the attack.	Day it disappeared.	Where recorded.
1	v. Graefe.	Macula lutea and a portion of the papilla.	14	30	Graefe's Archiv, V., 1, pp. 149–152.
2	Blessig.	Macula lutea, papilla and retina below the papilla.	Some hours.	Thirty days later still present.	Graefe's Archiv, V. III., 1, p. 219.
3	Schneller.	Vicinity of papilla slightly veiled.	....	....	Graefe's Archiv, VIII., 1, p. 272.*
4	Liebreich.	Macula lutea.	....	....	Graefe's Archiv, V., 2, p. 263.†
5	Liebreich.	In each of six cases opacity of the macula and the papilla.	1—6	6—?	Deutsche Klinik, 1861, No. 50, p. 476. Atlas of Ophthalmoscopy, Pl. 8, Fig. 4.‡
6	Steffan.	Macula and papilla.	4	40	Graefe's Archiv, XII., 1, pp. 37–38.
7	Saemisch.	Lower portion of retina.	2	5	Klin. Monatsbl., 1866, p. 34.
8	Schirmer.	Retina and papilla, no opacity around macula.	2	30	Klin. Mon., VI., 41.
9	Knapp. The last of the 5 cases can hardly be included.	1 } Macula and 2 } papilla. 3 } 4 No opacity.	5 1 2	19 .... 20	Graefe's Archiv, XIV., 1, pp. 210–220.
10	Knapp.	Retina, macula around the infarctus.	Observed 3 weeks after the attack of blindness.		Archives of Ophthal. and Otol. I., 1, p. 64.

* Schneller's case, distinguished beyond nearly all others by a considerable restoration of vision, came under his observation the twelfth day after the advent of the blindness.

† The case is described with much brevity, and hence allows no appreciation of its circumstances.

‡ The opacity constantly occurred, sometimes early, sometimes late, disappearing in like manner. Liebreich gives no further particulars.

A proper estimation of the derangements in the tissues that ensue on the occlusion of an artery is based wholly and entirely on "whether behind the coagulum, between it and the dependent capillary tract, there is given off an arterial branch that directly inosculates with any other artery, or whether such an anastomosis is wanting." * If the latter be the case, that is, if the occluded artery be a terminal one, its embolic occlusion may give rise to a double series of derangements, entirely independent of each other. "First, necrosis, the natural consequence of the cessation of circulation in an animal organ; secondly, engorgement, due to the reversed action of the current of the neighboring vein, a current impeded in the retina by no venous valves. The combination of both chains of deranged symptoms is the infarctus." †

This being the fundamental law, it is a source of surprise that the embolic infarctus of the retina should have been accurately noted in but a single case, while, on the other hand, it adds considerable force to the observation that this infarctus took place in connection with an embolism of a *branch* of the central artery, a branch of whose significance as a *terminal artery* there can be, according to Cohnheim's construction, no doubt. On reading the critical remarks appended by Knapp to his case, we gladly admit that he fell but little short of a solution of the whole process, the final theoretical verdict being reached by Cohnheim's experimental observation.

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* Cohnheim, l. c., p. 16.

† Cohnheim, l. c., p. 61.

To bring about an opacity of the tissue, which must be regarded as an optical evidence of necrosis, it is essentially necessary that the artery supplying the tissue concerned should be terminal, the occluded vascular region being, in any other event, simply eliminated from the circulation. If this be the stand-point from which we proceed in our consideration of the retinal circulation, we find at once that the authorities are at variance. While Cohnheim denominates the central retinal artery, at its point of departure from the papilla, distinctly terminal, referring to a point beyond the slight connections between it and the ciliary arteries that here traverse the optic nerve,* Leber says, "The small arteries which proceed from the plexus surrounding the optic nerve go in part inwards, to that portion of the nerve that lies before the lamina cribrosa, in part run more posteriorly into its trunk. Their connections with the branches of the central artery seem generally pretty minute. *Very minute branches are continued also into the retina in the immediate vicinity of the papilla.* It is therefore an established fact that the ciliary vessels contribute to the nutrition of the papilla and the adjoining portions of the optic nerve and the retina. Considering this appreciable vascular connection at the point of entrance of the optic nerve, it is astonishing that, after a complete embolism of the central retinal artery, no more considerable collateral circulation should be established." †

In accordance with these investigations of Leber,

* Cohnheim, l. c., p. 72. † Graefe's Archiv, XI., 1, pp. 6 and 7.

and as long as they are not controverted, must we base our faith, and hence allow the possibility of an undoubtedly imperfect supply of the retina from these ciliary connections, after an embolic occlusion of the central artery on the further side of the minute connections with the ciliary arteries, and regard only the branches of the central artery as terminal arteries in the full sense of Cohnheim's views. At all events, these direct connections between the ciliary arteries and the retina are so slight as to seriously compromise the nutrition of the latter when supplied from this sole source; and when we note the considerable amount of opacity that accompanies the closure of a branch of the central artery, the assumption will not seem forced that appreciable necrotic opacities of the retina, and consequent incurable destruction of its functional capacity, must result from an occlusion of the central artery at a point beyond the giving off of the ciliary connections. It is both theoretically probable and practically established that, in a necrosis of this kind, the primary impairment will be in the region of the macula lutea, a spot which in the normal state is particularly devoid of vessels. Should the necrosis recede as rapidly as it advanced, it is to be assumed that the embolus is situated at a point particularly favorable to the development of the ciliary collateral current, which collateral current may, as has already been indicated, be sufficient to arrest the necrosis and remedy the opacities that have already been induced, without being sufficiently ample to bring about a resumption of function. The period of occurrence of necrotic opacity of the tissue (aside from spe-

cific, infected embolisms) may thus become a valuable means of diagnosis for us in determining the locality of the vascular obstruction, and the clearing up of the opacity as accurate an index of the time and extent of the collateral connection.

A second point, about which authors exhibit many discrepancies, and which I am apparently allowed by the experiments of Cohnheim to view under a single aspect, is the form and contents of the occluded vessels. The following table (p. 64) bears thereupon.

This table exhibits wide variations in the abnormal state of the vessels, both as regards contents and shape. Although, in the majority of cases noted, the arteries appear appreciably narrowed, and exhibit from the centre towards the periphery a diminution in calibre, there are yet two cases that show a directly opposite state of things (Cases 2 and 7), the arteries being decidedly fuller at their peripheric distributions than at their centre. These two cases, that seem decidedly without the pale of typical embolism of the retina, are capable, on closer examination, not only of entire explanation, but furnish at the same time a clue to the occurrence of extravasations that we have to allude to farther on. For on comparing Case No. 2 with Figure No. 7 in Cohnheim's article,* we see that the whole affair amounts to a replenishing of the occluded artery by means of an arterial anastomosis from the ciliary plexus of the optic nerve, an explanation harmonizing fully with Blessig's remark that the greater fulness of the very contracted

* L. c., p. 16, and plate.

TABLE 2.

No.	Name of author.	Arteries.	Veins.
1	v. Graefe.	Extremely narrow lines.	Thin; their unequal fulness increasing towards the equator.
2	Blessig.	Small red lines; they contain a certain amount of blood some distance from the papilla; in most of them this amount of blood and their diameter *diminish* as the papilla is approached.	Narrowed and best filled towards the periphery; unequal fulness throughout their whole course.
3	Schneller.	Thin, red streaks confined within two *white* lines.	Narrow, growing *thicker* towards the papilla.
4	Liebreich.	*Wholly void of blood.*	Thin, becoming thick in the direction of the periphery.
5	Liebreich.	Thin.	Thin, tapering towards the point of emergence.
6	Steffan.	Thin.	Thin, tapering towards the point of emergence.
7	Saemisch.	Thin and quite *white*, at one place some blood is retained; above the white coloration an enlargement. On the tenth day after the advent of blindness some blood could be proved to be contained in the *peripheric* portions of the occluded arterial branch; the current advancing towards the centre, but still showing an interruption.	The corresponding vein is somewhat enlarged, especially towards the papilla.
8	Schirmer.	Very thin, the column of blood being nowhere interrupted.	On the papilla very thin, at some distance from it abnormally large, tortuous, exhibiting a type of stagnation.
9	Knapp.	1. Very thin and threadlike, quite rapidly decreasing in diameter in the direction of the periphery. 2. Threadlike, single in contour, not to be traced far beyond the papilla. 3. Very thin. 4. Thin, with a slight enlargement on the papilla.	1. On the papilla most narrow and very dark; thicker towards the periphery. 2. Very thin, larger towards the equator. Fulness equal. 3. Well filled, with shifting interruptions. 4. Rather thinner than normal.
10	Knapp.	Thin, like a fine red thread, that becomes suddenly transformed again into a ribbon with a double contour.	The corresponding vein enlarged and tortuous.

arteries began immediately beyond their passage over the edge of the papilla, that is, at the point where, according to Leber, branches of the ciliary arteries directly enter the retina. There results hence the extreme probability that the embolus had been carried down to a great depth in the central artery.

Case No. 7 possesses an entirely different significance. The phenomenon of decided arterial engorgement at the periphery is here presented, not at the commencement of the blindness, but as late as the tenth day. It is probably an instance of a retrogressive movement from the neighboring vein. "It begins at the point of union of the passive with the flowing vein, the latter emptying the greater portion of its contents in the normal direction of the heart, but passing, too, a certain quantity into the immovable venous branch, in a directly contrary direction.* In the case referred to, the vein corresponding to the branch containing the embolus was somewhat swollen, especially in the direction of the point of emergence from the papilla; the fulness of the occluded arterial branch began at the periphery and advanced gradually forward in the direction of the central extremity, *without, however, causing the interruption of fulness* to disappear. A similar explanation may be offered regarding the phenomenon of unequal fulness of the veins, with intermitting motion of their contents, observed in some cases (1, 2, 9, 3), inasmuch as Cohnheim has observed and described a similar intermitting movement, a going and coming, first occur-

* Cohnheim, l. c., p. 18. Fig. 6.

ring when the fulness of the veins has attained a certain height by means of the retrogressive current.*

We find, moreover, laid down in the table that the arteries at times appear thin, or like a fine red streak, or, again, like a fine red line bounded on either side by two fine white lines, or finally, like entirely white bands. As is well known, this utterly varying description on the part of single observers has led Stellwag von Carion in especial to express the doubt as to whether we have not, in the observations in question, to do rather with a perivascular inflammation than with an embolism. But the observations of Cohnheim allow us even here to array all the types described under the head of a general and final cause. A glance at his figures, 4, 5, 6 and 7, gives us the explanatory clue to the possibilities described. The explanatory text teaches us that the different types are simply due to the *rapidity* with which the occlusion takes place; according as the embolus suddenly obstructs the whole trunk of the vessel, or gradually increases from partial to total, so do we remark on either side of it now a tranquil column of red blood, again a tranquil red column behind, and a colorless column of plasma before the obstruction, and yet again a pale, colorless vascular trunk as a consequence of the embolism. And that a process of embolism may occur that *gradually* leads to an entire closure of the canal of the vessel, we find sufficient proof in the records of cases that treat of the obscurations preceding the attack of actual blindness.

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* Cohnheim, l. c., p. 19.

TABLE 3.

No.	Observer.	Number and form of extravasations.	Position of extravasations.	Day of occurrence after the attack.	Form of red spot at the macula lutea.
1	v. Graefe.	None.	None.	....	Cherry-red spot in the immediate vicinity of the foramen centrale.
2	Blessig.	Two ecchymoses, the one on, the other near, a retinal vein.	Around the macula lutea.	10	A red spot in the foramen centrale.
3	Schneller.	None.	None.	....	None.
4	Liebreich.	Small ecchymoses on the veins.	Around the macula lutea.	....	....
5	Liebreich.	Ecchymoses in all six cases.	Around the macula and papilla.	....	In all six cases without any detailed information, except that they were situated in the opacity of the macula.
6	Steffan.	Two small extravasations.	At the edge of the papilla, the one below, the other outwards	9	In the centre of the milk-white opacity.
7	Saemisch.	....	....	....	....
8	Schirmer.	....	....	....	At the macula a red spot, easily distinguishable from an extravasation.
9	Knapp.	1. Numerous, striped and spotted.	In the opaque retina, around the macula, extending to the papilla.	5	....
		2.	....	....	A cherry-red place around the yellow spot.
		3. One hemorrhage.	Close in the vicinity of the upper edge of the papilla.	2	A small dark-red spot on the macula.
		4.	....	....	....

We have yet to consider a symptom by no means constant, namely, that of *extravasation*, with which we

will connect a discussion of the much-argued question as to the red coloration of the favea centralis. Let us then seek to derive from a table some information as to the frequency of extravasation. (See page 67.)

With these cases must be ranked Knapp's observation of the infarctus, made three weeks after the advent of blindness, and in which the numerous hemorrhages *were situated around small venous branches.* The red spot at the macula is recognizable, it is true, on the colored plate, still is markedly different from other descriptions and representations. Of its significance as an ecchymosis there is in this case no doubt.

In the above 28 cases the table exhibits to us 12 instances of ecchymosis, which vary not inconsiderably in number and in size. Their site is generally about the macula lutea, sometimes in the neighborhood of the papilla. On comparing the last table with table No. 1, it becomes evident that, in all cases in which ecchymoses are noted, their sites exhibit proof of necrotic changes of tissue. In 3 cases the hemorrhage is expressly described as proceeding from the retinal veins. As regards, finally, the period of occurrence, we unfortunately find no details given in the most cases; according, however, to the positive observations made in some cases, it happens generally several days after the embolic obstruction. In but a single case (Knapp, No. 3) do we find allusion to an extravasation close to the papilla the day succeeding the sudden advent of blindness.

On collating now these several data and comparing them with the results of the experiments of Cohnheim,

I think we shall find no difficulty in passing judgment on them from a single point of view. It has already been stated that no theory of an arterial hemorrhage in consequence of the collateral fluxion, succeeding the occlusion of the principal branch, can obtain, all the less, indeed, because this collateral fluxion would have to be greatest after the occlusion, and diminish or entirely disappear in proportion as time went on.* The case must be one, therefore, of extravasation from the veins or capillaries, described by Cohnheim as the result of venous accumulation, combined with necrosis of the tissue or vascular walls, and to be regarded as paving the way to an infarctus. A properly typical picture of this infarctus has been furnished us by Knapp, and it is certainly to be regarded as a triumph of ophthalmoscopic observation that the embolic infarctus should be, in this case, pointed out to be a venous extravasation, in entire opposition to the views previously obtaining. This observation has in itself fulfilled the second portion of the hope expressed by Virchow, and cited in the introduction to this article, and the experimental investigations of Cohnheim have rendered possible the pathogenetic elucidation of its mechanical details. Blessig, too, was on the scent of the right solution. "The extravasations occurred subsequently to the dissolution of the retinal elements. This later appearance, as well as the circumstance that hemorrhages into the parenchyma took place only on those portions of the retina that were opaque, and hence liable to be more

* Cohnheim, l. c., p. 88.

thoroughly and quickly affected by the derangement of nutrition, go to prove that the dissolution of the tissue must have been a primary, and the hemorrhage into the degenerated and softened retinal tissue a secondary, symptom. I lay great stress upon this circumstance, because the occurrence of hemorrhagic processes in the vicinity of arteries occluded by embolism is generally explained on the theory that collateral fluxion causes the blood to collect in the region of the occluded arteries, and ultimately brings about a rupture of the vessels." * Although this theory nearly approaches the one of Cohnheim adopted by us, we still see from the sentence immediately following this explanation how slight a conception Blessig had of the *mechanical* concomitants of extravasation, and how this depended on the lack of experimental microscopical observations. For he goes on to say: "It is perhaps a consequence of the sparse collateral communications in the vascular tract of the central artery of the retina, that more pronounced and extensive parenchymatous hemorrhages have not been noted in embolism of the same." The picture drawn by Knapp of retinal infarctus may be considered typical according to the views of Cohnheim, and in the critical analysis of the case there is nothing wanting except the retrogressive venous current from the neighboring vein, a knowledge of which indeed could hardly be theoretically attained. If, on the other hand, it is demanded why extravasations are not met with in all cases in which necrosis of the retinal tissue

* Graefe's Archiv, VIII., 1, p. 224.

is found, I would refer to the frequently cited article of Cohnheim,* which contains an exhaustive discussion of the circumstances in question.

We have still to discuss the inquiry as to whether the red spot at the macula lutea, that has grown to be an almost pathognomonic indication of embolism of the central artery of the retina, is to be interpreted as a phenomenon of contrast or a hemorrhage. We find it noted thirteen times in the eighteen cases of the table, and are justified in distinguishing between it and the infarctus, an indubitable hemorrhage into the retina. Among these remaining twelve cases we find the red spot associated eleven times with a white discoloration of the macula lutea. The only time that the red spot existed, without opacity of the macula lutea, we find expressly stated that "a reddened place is met with on the macula lutea, *between which and an extravasation there is a distinct difference.*" (Case 8, Schirmer.) In another of these cases (9, Knapp's third case), an ecchymosis at the upper edge of the papilla is described, and then a small, dark-red spot on the macula lutea alluded to; a similar coincidence occurs, moreover, in Blessig's case: one would think that the question of likeness or dissimilarity would be easily decided, owing to such an immediate juxtaposition of two red spots. In considering Steffan's discussion of the present question,† it is presently discovered that this is based on a false mechanical principle, that of arterial collateral fluxion, and, with its result, the formation of extravasation

* L. c., pp. 85–88. † Graefe's Archiv, XII., 1, pp. 39–47.

in the choroid, must be held erroneous; hemorrhages from arterial fluxion having been proved by Cohnheim untenable. Looking now at the table with a view of ascertaining the form of development of this red spot in the several cases, we find the description to present no inconsiderable variations. At one time there is a cherry-red spot in the immediate vicinity of the foramen centrale, at another situated on the foramen centrale itself; sometimes it is described as on the macula, and sometimes indeed as around it. In the case I myself observed I found it red, with a granular surface, indistinct boundaries, entirely unlike an extravasation, with no parallax to be made out between it and the neighboring retinal veins.* The red coloration was most intensive in the middle, corresponding to the fovea centralis, and passed through a succession of less brilliant shades till it merged in the normal fundus. Its disappearance was gradual and equal on all sides, the red color slowly melting into the ordinary yellow-brown. The impression made on me by the red patch, I have already described as entirely dissimilar to that produced by an extravasation, and I am very well able to conceive how, when a whitish coloration occupies all of the yellow spot but the fovea centralis, the intensely red centre must appear as a hemorrhage. Inasmuch now as I find no anatomical foundation for a venous hemorrhage in the region, and especially the centre of the macula lutea; inasmuch, moreover, as no veins quit the

* It seems almost incredible that the binocular ophthalmoscope should be neglected, as a means of diagnosis, in such cases, and a "parallax" gravely alluded to in determining differences of level.—TRANSLATOR.

choroid at the portion posterior to the macula lutea; *inasmuch, however, as the most numerous and vigorous twigs of the short posterior ciliary arteries enter the choroid exactly at the posterior pole,** it is easily seen that the collateral fluxion succeeding the embolism may attract especial notice by its deep-red color, exactly at the point where the vessels are still closely packed together, since this fluxion consists in an acceleration of the current of blood through arteries dilated under an increased pressure, *without any extravasation through the arterial walls being yet brought about.* Inasmuch now as the middle of the yellow spot is colorless, nearly wholly transparent, and at the same time the thinnest portion of the retina,† the normal appearance of the fovea centralis is that of a dark-red spot; if now, on the other hand, an increased redness of the choroidal polar region occurs, the color of the fovea centralis must naturally increase. When, as in my case, this red color embraces the whole macula lutea, in gradually decreasing intensity indeed, and without sharply-defined boundaries, I find in exactly this circumstance an increased support of the theory advanced: for in the first place the thickness of the remainder of the macula lutea is more considerable than that of the fovea centralis, and in the second place the boundaries of the yellow spot are never as sharply defined in old

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* Leber. Investigations concerning the course and connections of the vessels in the human eye. Graefe's Archiv, XI., 1, p. 14.

† H. Müller. Anatomic-physiological investigations concerning the retina of men and vertebrates. Zeitschrift für Wissensch. Zoolog., VIII., p. 1–122. Gesammelte Abhandlungen, p. 308.

people as in children; from the last circumstance it necessarily results that the superjacent retinal pigment must cause the circumscribed hyperæmia of the choroid to appear somewhat diffuse. This explanation is favored, too, by the gradual and equable disappearance of the red color, without the occurrence of any perceptible change of tissue.

COLOGNE, November, 1872.

ON A PARTICULAR FORM OF HEMORRHAGIC GLAUCOMA.

By Dr. SHROEDER,

IN WIESBADEN.

(Translated by Dr. Joseph Aub, of Cincinnati.)

[This paper was read before the Medical Society of the Middle Rhine, at Frankfort on-the-Main, the 22d day of May, 1872.]

The subject, "On a new form of glaucoma," should not attract the attention of specialists alone, but that of general practitioners; for glaucoma is one of those diseases which form the connecting link between the general practitioner and the oculist, and which should be well understood by the former. When such is the case we may expect that the diagnosis will be made in proper time, and the percentage of glaucomatous blindness will be greatly reduced.

The different classifications of glaucoma made by v. Graefe and Donders are generally known. The cause of the disease is supposed to be a condition of hypersecretion in the interior of the eye, occasioned by irritation of the vaso-motor nerves, and especially the trigeminus. I do not desire to enter into the discussion about the origin of glaucoma, yet feel impelled to call attention to the simple, *i.e.*, the primary, chronic, non-inflammatory glaucoma, and ask where in this case does the primary irritation of the vaso-motor nerves exist? Here you cannot demonstrate the usual causes of sec-

ondary glaucoma, as, for instance, synechiæ, a swollen lens, etc., which could cause a traction of the nerves, followed by hypersecretion. And yet the increase of the intra-ocular pressure and the characteristic excavation of the papilla are there just as well. The explanation of an irritation of the vaso-motor nerves will not hold good for this form of glaucoma.

I hope you will agree with me that in explaining the nature of glaucoma, at least of simple glaucoma, the conditions producing a hypersecretion have been highly overestimated and the absorption of the fluid secreted within the eye has been almost entirely lost sight of. The tension of the eyeball does not need a hypersecretion to become increased; for this purpose a diminished power of absorption will suffice.

Taking into consideration, therefore,

1. That such a condition exists in senile eyes in consequence of the sclerotic degeneration of the walls of the blood-vessels; and

2. That glaucoma simplex occurs almost without exception in such eyes,

I came to the conviction by way of exclusion that for this disease the senile diminution of the power of absorption was the most important, if not the only, etiological factor.

If the primary cause of the increase of the intra-ocular pressure once exists, the consequence will be a hypersecretion which keeps up the glaucomatous condition by stretching of the nerves or by placing some mechanical obstacle in the way of the current of blood through the veins of the eye.

The form of glaucoma which will be the principal topic of this paper, and which is designated by the name of *hemorrhagic glaucoma*, is less known than the common forms. It derives its name from hemorrhages which occur in the retina. I will state in a few words what has been written on the subject, in order to distinguish and define clearly the form which I wish to describe.

The affection under consideration is not of frequent occurrence: v. Graefe observed it in 22 cases; Laqueur describes 7 cases of hemorrhagic glaucoma among 268 cases of glaucoma in general. In the statistics of glaucoma which I compiled in Utrecht, with the permission of Prof. Donders, there was not a single case of this kind described. The majority of the patients were of an advanced age. Occasionally atheromatous degeneration of the arteries, and in one case (Hirschberg) a disease of the heart, were demonstrated.

The retinal hemorrhages generally precede the commencement of the glaucomatous trouble by ½—6 months. The glaucomatous attack itself commences with severe ciliary neuralgia; its hemorrhagic origin can frequently enough be proven even in this stage of the affection. The disturbances of vision may manifest themselves in the most varied forms. Some have observed an excavation of the papilla, whilst others have not. Iridectomy has proved futile. As a rule, enucleation was made.

Coccius described, in the *Arch. f. Ophth.*, B. IX., 1, p. 8, a case of hemorrhagic glaucoma, in which the glaucoma followed two days after the commence-

ment of the retinal process, and in which iridectomy had a most excellent result. v. Graefe declares this result exceptional, and thinks, in my opinion without cause, that the interval between the beginning of the retinal trouble and the glaucoma was likely a longer one, and that the retinal hemorrhages may have existed for several days before an additional hemorrhage produced the disturbance of vision which attracted the attention of the patient. Laqueur (*Annales d' Oculistique*, T. LXI., p. 56–57) has also observed cases of hemorrhagic glaucoma, in which the suddenly occurring retinal hemorrhages instantly caused glaucoma, combined with severe ciliary neuralgia. In this case the hemorrhagic infiltration of the vitreous rendered an ophthalmoscopic examination of the fundus oculi impossible. I will endeavor further on to explain why, in this case, the iridectomy was a failure.

The following case, in which I successfully performed an iridectomy, does not seem unfit to complete the cases so far known:—

Mad. C——, of Wiesbaden, aged 62, consulted me on the 23d day of February, 1872, by the advice of her family physician, for sudden blindness and violent ciliary neuralgia, which had set in two days previously. Until then that eye had enjoyed excellent sight, whilst the right eye had been lost in consequence of chorio-retinitis, with pigmentary deposits in the retina. Functional examination of the left eye showed the vision reduced to quantitative perception of light; objective examination revealed the existence of increased intra-ocular pressure, diminished sensibility of the cornea, shallow anterior chamber, dilatation and immobility of the pupil, with the characteristic glaucoma reflex from the pupil. A general diffuse (serous) opacity of the vitreous prevented an ophthalmoscopic examination of the fundus

oculi. It was evident that I had to deal with a case of acute inflammatory, primary glaucoma. I recommended iridectomy as the only remedy. On the following day I made the operation without any accident, and it was followed by an immediate and continued diminution of the intra-ocular pressure to the normal state.

Two days following she counted fingers in 3′; after three days in 5′, and after five days in 8′. On the eighth day, with +10, she could read Sn. No. 2. On the 20th of March the sight of the eye (which had hypermetropia $\frac{1}{8}$) was almost $\frac{1}{10}$. The field of vision was curtailed inwardly. An examination made three months after the iridectomy showed the same acuteness of vision. The field of vision was contracted inwards to within 4″ of the point of fixation, when the distance of the visual object was one foot.

The opacity of the vitreous, which was of a serous, not a hemorrhagic nature, disappeared three days after the operation. Its occurrence I seek to explain by supposing that hyperæmia occasioned serous infiltration of the retina, followed by serous exudation into the vitreous itself. In the now discernible fundus oculi an intensely red, round hemorrhagic spot, half the size of the papilla, appeared between the disk and the macula lutea; the retina in its vicinity was slightly clouded and swollen, and the two arteries which generally run parallel from the papilla to the macula lutea were not to be seen. The papilla was reddened by capillary hyperæmia. No signs of a complicating choroidal trouble. The first idea suggesting itself was that this was a case of primary, acute, inflammatory glaucoma, and that the hemorrhage had occurred after the iridectomy. It is true that retinal hemorrhages seldom are absent in cases of cloudiness of the media and decided increase of tension; however—

1. Under the existing relatively moderate increase of tension in our case, secondary hemorrhage could not be presupposed as a matter of necessity.

2. Those ecchymoses which follow iridectomies, and which appear most frequently in the neighborhood of the macula and papilla, are smaller than the one in our case; and

3. They always occur in greater numbers; occasionally they are scattered over the whole fundus.

4. The other conditions observed with the ophthalmoscope, viz.: cloudiness and swelling of the retina, and redness of the papilla, indicate that a retinal trouble was the cause of the glaucoma.

To this I will add the description of the ophthalmoscopic condition of the fundus on the 19th of May. Papilla moderately white, its margin here and there ill-defined, surrounded by pigment on its inner side. Vessels of the retina, arteries as well as veins, narrow and sharply defined. The former hemorrhage is almost entirely absorbed, yet no white discoloration in its place; diffuse atrophy of the pigmentary layer; choroid normal. It is hardly possible to think of the retinal hemorrhages as having occurred during the operation, for this would be followed by an enormously increased intra-ocular tension; whilst in our case normal conditions of tension could be demonstrated immediately after the operation.

The above-described condition of the retina establishes the fact that the case before me was one of hemorrhagic glaucoma, which differed, however, in several important points, from the common hemorrhagic glaucoma, and closely resembled the cases of Coccius and Laqueur. To render this fact conspicuous, I determined to compare the symptoms of these cases and the one just related, with the symptoms of the common hemorrhagic glaucoma, and from this comparison came to the following conclusions.

The cases on record can be divided into two groups: the larger one comprises the 22 cases of v. Graefe and the cases described by Wecker, Horner, Becker, Hirschberg and Soelberg-Wells; the other and smaller group consists of the cases described by Coccius, Laqueur, and myself. The first form would be sharply enough defined by the name of "hemorrhagic glaucoma with a prodromic stage," or "secondary hemorrhagic

glaucoma;" whilst for the latter and rarer form I would suggest the name "acute hemorrhagic glaucoma," or "primary hemorrhagic glaucoma."

My reason for making this division will be seen in the following arrangement of differential diagnosis:—

The secondary hemorrhagic glaucoma	*The primary hemorrhagic glaucoma*
1. Has a preliminary stage related to the affection of the retina, and may last 6 months.	1. Has no preliminary stage; the occurrence of the retinal hemorrhages occasions the glaucomatous condition without delay.

[It is very difficult to explain the fact that but a limited number of cases of apoplectic retinitis become complicated with glaucoma; we might explain it as we explained the occurrence of glaucoma simplex, by assuming a diminished power of absorption in the vascular system of the retina. The supposition of diminished absorption is not a mere speculation, but is borne out by pathological anatomical investigations which have shown infiltration of serum and extravasation of blood in the retinal tissue, furthermore thickening of the walls of the blood-vessels, producing contraction of their calibre, resulting undoubtedly in a diminution of the power of absorption. (See farther below.)

The senile rigidity of the sclera must likewise be of importance in this process.]

The secondary hemorrhagic glaucoma	*The primary hemorrhagic glaucoma,*
2. Is easily diagnosed, for the impairment of vision as produced by the primary lesion in the retina causes the patient to consult the physician at an early period. The glaucoma develops, as it were, under the eyes of the physician.	2. With the exception of Coccius's case, cannot as such be diagnosed, for it presents the appearance of primary acute inflammatory glaucoma. It is only after the vitreous body is sufficiently cleared that we can make the differential diagnosis.
3. It may cause the most varied forms of amblyopia which depend on the degree of the retinal hemorrhage, and secondly on the intensity of the secondary glaucomatous affection. Defects of the visual field may be present or absent (*Hirschberg*, first report of his Eye-Clinic, and *Soelberg-Wells*, Klin. Monatsschrift f. Augenheilk., VII., 398). This is sufficient to refute the erroneous assertion that defects of the visual field do not occur in hemorrhagic glaucoma.	3. The power of vision is usually reduced to the quantitative perception of light.
4. This form of glau-	4. In cases of primary

coma is not only not benefited by iridectomy, but assumes even a worse aspect; and the operation at the same time increases the liability of the other eye to become affected with the same process. The only case of hemorrhagic secondary glaucoma in which iridectomy was of any benefit is the case which *Becker* reported at the Ophthalmological Congress held in Heidelberg in 1869. This was originally a case of nephritic retinitis which formed the premonitory stage of the glaucoma, and was followed by an acute glaucomatous attack, with violent ciliary neuralgia. Iridectomy relieved the pain, but it is not stated whether it reduced the tension of the eyeball and improved the vision.

It is easy to account for the uselessness or rather the injurious effect of iridectomy in secondary hemorrhagic glaucoma. What is said of the hemorrhages consequent upon iridectomy in other forms of glaucoma, holds hemorrhagic glaucoma, iridectomy has, without a doubt, a beneficial effect when made at an early date, as in Coccius's case and my own. In my case the acuity of vision of the operated eye was $\frac{1}{2}$, and with + 10 Sn. No. $1\frac{1}{2}$ was fluently read. There is no doubt that Laqueur delayed the operation too long.

good here as well; the removal of the pressure by the evacuation of the aqueous humor produces dilatation and rupture of the blood-vessels. This hemorrhagic tendency is favored by a degeneration of the retinal tissue.

It is more difficult to account for the beneficial effect of iridectomy in primary hemorrhagic glaucoma. Yet some reasons may not be without weight:

1. The retinal trouble having existed but a short time, a degeneration of the retina, predisposing to hemorrhages, has not yet taken place. If, on the other hand, the trouble has existed for some length of time, we likewise find iridectomy useless, as in Laqueur's case.

2. The operation causes a diminution of the intra-ocular tension, removing secondarily the paralysis of the retina occasioned by pressure, and admits of a freer circulation and absorption.

Of late, attempts have been made to loosen the connection between hemorrhagic retinitis and glaucoma, because in a very large number of cases the former does not lead to glaucomatous conditions. In answer to this we may say that glaucoma is but a symptom of the disease in question, and may be wanting in certain cases without losing its importance where it exists. Does it not frequently happen that in marked cases of morbus Brightii, the well-known nephritic retinitis is wanting? and yet no one would think of disputing the causative connection of this retinal trouble and the renal disease.

I cannot, either, approve of the assertion that a relation of cause and effect between the retinal affection and glaucoma could not be admitted, on account of the indefinite length of time which is apt to intervene between the commencement of the two diseases, and in some cases is of so long a duration that the appearance of glaucoma must be considered as purely accidental.

The occurrence of the glaucomatous symptoms depends upon a disturbed relation between secretion, absorption, and elasticity. These symptoms will manifest themselves the sooner the more the secretion is abundant, the power of absorption reduced, and the resistance of the coats of the eye increased. If, for instance, we have to deal with a moderate effusion of blood causing either no retinitis, or retinitis of slight intensity only, the age of the patient being not much over forty, we need not fear glaucomatous complications. It is only after long continuance of the retinal trouble, the anatomico-pathological consequences of which consist in a decrease of the power of absorption within the area of the retina, and when additional hemorrhages take place, that the elasticity of the sclera will become inadequate to counterbalance the increase of the contents of the eyeball and augmentation of tension is discernible by the touch with the finger.

A smaller quantity of extravasated blood will suffice to produce glaucoma, if the power of absorption is reduced and the elasticity diminished.

It is self-evident that these conditions must have prevailed to a high degree, in our case, to cause glaucoma

to manifest itself at once with the retinal hemorrhage. The considerable increase of the contents of the globe occasioned by the swelling and hemorrhages of the retina, the infiltration into the vitreous, and the senile rigidity of the sclera, seem, indeed, sufficient to cause the simultaneous appearance of glaucoma and retinal hemorrhages. The power of absorption in the retina, owing to the short duration of the affection, which could produce no great alteration in the stroma of the retina, was but slightly disturbed. This explains also the favorable result following the iridectomy.

But that, as a rule, the so-called hemorrhagic glaucoma should be dependent on the retinal trouble, is proved by the conditions found in those eyes which have been enucleated on account of hemorrhagic glaucoma with violent ciliary neuralgia. Pathological changes could only be found in the retina, whilst all the other parts of the eye were normal. These changes were described by *H. Pagenstecher* (*Arch. f. Ophth.*, XVII., 105–106, 110), and furnish the anatomico-pathological basis for my theory of a diminished power of absorption. See the first report of my Eye-Clinic at Nerothal, Wiesbaden, p. 15.

Thus far we have been discussing the seat of the disease producing glaucoma; the question now presents itself to us, whether we should separate the secondary hemorrhagic glaucoma from the other glaucomatous processes, because in most cases of this form iridectomy has proved ineffectual. I think it inadmissible to make the effect of a remedy the basis for the classification of the disease. He who looks upon glaucoma as a

symptom, and operates for the purpose of relieving that symptom, will readily agree that the success of iridectomy will depend upon the character of the original trouble; and if he has had occasion to perform iridectomy in different forms of glaucoma, he will have found that in one form the failures will have been more numerous than in others; but still he will not feel justified in excluding that form from the group of glaucoma. The success of iridectomy will of course be different in different forms; and in tabular statements, which are arranged according to the results obtained, the secondary hemorrhagic glaucoma will certainly rank last.

REMOVAL OF TWENTY-EIGHT SMALL GRAVEL STONES, WHICH LAY SEVEN YEARS IN BOTH EXTERNAL AUDITORY CANALS.—RECOVERY.

By SARA E. BROWN, M.D.,

OF BOSTON.

On the 22d of July, 1873, I was called to see John Smith, of Clinton, Mass., aged sixteen, an inmate of the School for Feeble-minded Youths, at South Boston, Mass. His general health and physical development were good, but his hearing was so much impaired that he could not hear his own voice, and was consequently losing his speech. Previous to the age of nine years his hearing was perfectly good; but about that time, while at play, he filled both ears with gravel stones. Those found in the outer part of the meatus were removed at the time by his mother, but those crowded in beyond the junction of the cartilaginous with the osseous portion of the canal, had remained there undisturbed for *seven years!* On examining the left ear, only a dark mass, completely closing the narrow part of the passage, was visible; but after syringing away a thin coating of cerumen the obstacle, when touched with a probe, proved, by a sharp, grating sound, to be a smooth, flat stone, partially embedded in the integument. So firmly was this pressed into the canal, that it was only after an hour and a half of patient work with the probe, and repeated syringing with warm water, that it was finally loosened and removed. A little more manipulation and syringing brought out a small, square stone, followed by one of larger size, having a very sharp, almost cutting edge. The first stone, a diamond-shaped bit of slate, measured on the longest surface half an inch, and transversely, from point to point, three-eighths of an inch, and is one-eighth of an inch thick. The second stone, somewhat wedge-shaped, measured from point to base one-

quarter of an inch, and the circumference around the largest diameter was three-quarters of an inch.

On the second visit, July 25th, two large stones and a piece of anthracite coal were removed from the right ear, and one small stone from the left. The appearance of the right ear was much the same as that of the left, only the stone blocking the opening presented a smooth, convex surface; it was also firmly impacted and held by the surrounding integument. After many trials it was pushed inward at the lower edge, and by further manœuvring so loosened and changed in position, that at last a well-directed stream of water lodged it where it could be seized by the forceps. This stone proved to be of triangular form, having one flat surface; its longest edge measured one-quarter of an inch, the other two edges three-eighths of an inch each; thickness, one-quarter of an inch. The irregular, cube-shaped piece of coal, with its sharp, glistening edges, was two lines over one-eighth of an inch thick; was one-quarter of an inch on the longest side, and had a circumference of seven-eighths of an inch. On the three succeeding visits, twenty-four other stones were removed, making twenty-eight in all—thirteen from the left ear and fifteen from the right. Eight of the stones were nearly as large as the ones of which the measurements are given; five of them but a little smaller, nine half as large, and but two very small ones, and those the size of the head of a large pin. Their aggregate weight was forty-two grains.

The inner portion of the external auditory meatus of both ears is of larger size than usual, and the space between the membrana tympani and the narrowest portion of the auditory canal is disproportionately large; in fact, there is a large chamber showing the impression of some of the stones which have lain embedded in it so many years. Both the membranes are whole, and do not appear to have been broken, but bear the prints of the edges and points of the gravel. In the right ear the membrane is very concave, and apparently much thickened; the epidermis, continuous with the canal and covering the external surface of the membrane, has, by the low, subacute form of inflammation, induced by the irritation and pressure, become opaque and thickened, save where the points and edges of the stones have pressed, and there the membrane is comparatively thin and clear, giving it a mottled or spotted appearance.

On uncovering the membrana tympani, as was done on the second visit, it was found so stretched and relaxed, that pressing on it with the probe caused it to wrinkle in every direction, and at one point the inner wall of the tympanic cavity could be touched. Examination at the last visit, August 15th, shows that the membrane has contracted, and has considerable tension; the manubrium may be dimly seen, and the short process of the incus indicated. In the left ear the membrane is less affected; the handle of the malleus, the plexus of blood-vessels, and the cone of light, are clearly visible. Near the margin of the membrane, in the posterior-inferior segment, a crescent-shaped portion is quite clear and thin, and looks as if wholly unharmed; but the remainder of the membrane has a marbled appearance similar to that of the right ear.

In the left ear the hearing distance for the watch is eleven inches; that of the right six inches, while he hears the voice at thirty-two feet. Since regaining his hearing his mental condition has much improved. He now carries his head erect, and the entire expression of his face and person is more manly and intelligent, and his speech also is being rapidly restored.

BOSTON, *August* 28, 1873.

CONTRIBUTIONS TO THE PATHOLOGY OF CHOROIDITIS.*

By Dr. H. F. B. KQRTÜM.

(Translated by Dr. Chas. S. Turnbull.)

Although the choroid may be readily examined with the ophthalmoscope, and choroiditis is by no means rare, yet a complete and accurate description of the inflammations of this tunic is wanting.

Every observer knows the ophthalmoscopic appearances, often so striking in choroiditis, but its different forms have neither been fully specified nor has their etiology been sufficiently traced.

In the later text-books the varieties of inflammation of the choroid are generally specified as serous, plastic, atrophic, and purulent, which may again be subdivided into diffuse and circumscribed (disseminate), and acute and chronic forms. This arrangement may answer, but there has not been so much attention paid to their classification as to their etiology; I do not therefore consider it superfluous to publish cases with details minutely noted. I will here attempt, by relating some histories, to illustrate certain forms about which comparatively little is known.

I. Choroiditis Congenita.

Case 1.—Ida J., æt. 10 years, was brought to *Dr. Hirschberg's* oph-

* This paper is the "Dissertatio Inauguralis" of the author, and is inscribed to *Dr. Hirschberg.*

thalmic clinique on the 27th of February, 1871. She has never had good sight, and of late a conspicuous alteration of the left eye had been noticed. The mother, with the rest of the children, were healthy, never having had any disease of the eyes. The father, otherwise healthy and strong, has been near-sighted since a boy, and has been completely blind in his *right* eye for at least eleven years. His vision must have diminished gradually, as he only discovered, whilst travelling, and attempting to use a telescope, that he was blind in that eye; and says that *Von Graefe* pronounced it an affection of the retina and gave an unfavorable prognosis.

The eye being examined showed only quantitative perception of light. The ophthalmoscope revealed atrophia nervi optici (ex neuritide ?), the optic disk being of a dull whitish color.

With the *left* eye he read Jaeg. No. 1, ab 4″, and showed no ophthalmoscopic changes other than those necessarily connected with a high degree of myopia.

Up to this time the child's eye had not been carefully examined, and it could not be determined when the *left* eye became totally blind. An opacity in the lens of the left eye had only been noticed during the last few months.

Status præsens. The girl is small, delicate and anæmic, but all her functions, excepting sight, are normal.

A. The *left* eye is of normal size and shape, pupil of medium width, with a delicate posterior synechia above, the lens grayish white, shining and shrunken, T. not materially diminished, no perception of light.

B. With the *right* eye reads Jaeg. No. 5 slowly at a distance of 4 to 5″ visual field apparently complete. Ophthalmoscopic examination shows the media clear, but there are marked changes in the fundus. The optic disk is reddish, its borders are ill-defined and slightly indented upward and outward in the inverted image. The distribution of vessels is normal, with a scarcely noticeable physiological excavation. Between the optic disk and the macula lutea, but nearer the disk, is a large white patch the size of about one quarter of the disk, and surrounded by other smaller patches, which by their glistening appearance manifest themselves as choroidal atrophies. Somewhat further inward (in the inverted image),

and almost in the centre of the background, is a very large white shining atrophic spot, about four times the diameter of the disk, with black stripes and patches in its area and on its borders. Nearly one diameter of the papilla to the inner side, is a long stripe characterized as choroidal atrophy, the retinal vessels passing over it. This stripe, which extends a considerable distance both upward and downward, has serrate borders, and is surrounded by numerous smaller white patches. There are numerous punctate spots, having the same appearance as the larger patches, seen along the retinal vessels, and above is one of a peculiar, white, shining color.

The *diagnosis* was choroiditis of long standing, probably congenital, followed in the right eye by detachment of the retina and secondary cataract.

The *prognosis* was unfavorable, and the hopes of the parent as well as those of the family physician, that sight could be restored by operation upon the cataractous eye, were not sustained. Recovery or marked improvement in the right could not be expected; on the contrary, there was danger of its growing worse.

The *treatment* consisted in moderate abstractions of blood by Heurteloup's artificial leech, small doses of bichloride of mercury, and iodide of potassium, with complete rest of the eyes.

Sight of the *right* eye was slightly improved, and has remained so. June 10th, child could read Jaeg. No. 4 at 4″. As the parents desired the cataract removed for cosmetic effect, if for no other reason, it was extracted. An incision was made with a lance-shaped knife, and the thickened capsule withdrawn with the capsule forceps, and the substance of the lens removed by pressure. The wound healed promptly, and a detachment of nearly the entire retina could now be made out.

Case 2.—Hermann N., æt. 12 years, of Berlin, was brought to the clinic on the 15th of July, 1870.

History. Father of child, æt. 46, also complains of gradual impairment of vision in both eyes for the last ten years, and counts fingers at 4′ with either eye. Iris discolored, pupil contracted, posterior synechia, and cortical cataract. Fundus could not be examined, but there could be no doubt of the diagnosis of irido-choroiditis. Had contracted an ulcer upon his penis, but no other history could be

ascertained, and no symptoms were now to be made out. An iridectomy was made downward with a narrow knife, and so the further decrease of visual power was arrested, and some improvement even ensued, which, as the opacity of the lens did not notably increase, will be comparatively permanent.

The boy has had poor sight since infancy. *Status præsens.* Reads Jaeg. No. 5 at 4″ with the *left* eye, and Jaeg. No. 14 with the *right* eye at the same distance. There is no appreciable defect in the visual field. There is nystagmus oscillatorius more pronounced in the right than in the left, and divergent strabismus of the *right* eye of 2 to $2\frac{1}{2}'''$. Well-advanced choroidal changes in both eyes are seen with the ophthalmoscope, most extensive in the *left* and better eye, so that the higher degree of amblyopia of the *right* eye must be considered as dependent upon the squint. In *right* eye are large white stripes with black dots and small patches like those found in choroiditis disseminata. In *left* are similar but more marked changes, and one broad, grayish-white, slightly prominent stripe, passes above and near to the papilla, slightly veiling the retinal vessels, looking like newly-formed connective tissue.

The first step of treatment was to make tenotomy of the external rectus, which resulted in considerable improvement of the sight of the *right* eye, with which he could now read Jaeg. No. 5 with +6. It is to be regretted that the reading exercises were not kept up with the requisite assiduity, and, as a consequence, the sight of the *right* eye gradually diminished. (Correcting a squint with mathematical accuracy can only be accomplished by training the binocular vision.)

On February 6, 1871, after a long interval, the patient was again presented, almost totally blind. About two weeks previous, sight had grown much worse, so that he was compelled to absent himself from school for one week, during which time his mother treated him with aperients, under which he improved so as to be able to resume his studies for another week. Two days ago impairment of sight again set in, and he saw less than ever.

Externally the eyes appear normal. With the *right* eye he counts fingers in 4′, and reads some letters of Jaeg. No. 16 eccentrically, and upon directing the visual axis inward, counts fingers in every direction. With the *left*, he counts fingers at 6″, and there is a large defect

of the visual field upward. The pupil cannot be illuminated when the visual axis is directed forward and downward,* but only when it is directed upward can a red reflex be obtained from the fundus. After dilating the pupil by oblique illumination, there are seen on the posterior surface of the transparent crystalline lens some very delicate red stripes and dots, which are evidently small hemorrhagic deposits.

The *diagnosis* of hemorrhage into the vitreous was obvious. The etiology of this, as is well known, rare occurrence has not as yet been cleared up. In certain cases it can be traced to anomalies of menstruation or disturbances of circulation, while in this case the cause could be referred to a previously diseased condition of the choroidal vessels. Rest in a dark room was enjoined, and applications of ice for fifteen minutes every two hours. (Internally, extractum secalis cornuti aquosum, one grain three times a day.) An artificial leech was applied to the left temple.

The boy exclaimed joyously the first evening that he saw better. Ophthalmoscopic examination showed, when the visual axis was directed upward, large black membranes floating in the vitreous. With oblique illumination, loose red blood-clots were seen to float behind the lower margin of the lens. February 9th.—Dose of ergot doubled. Heurteloup to *left* temple, and cold applications. Some retinal vessels can be seen when the patient looks upward. February 10th.—With *left* eye counts fingers at 7′. February 20th.—Heurteloup again, and ergot having been continued, counts fingers across the room with *left* eye. February 27th.—Reads Jaeg. No. 16 with the *left* eye, aided by +6. The papilla is now visible. March 1st.—Reads Jaeg. No. 7, with +6. Mar. 4th.—Reads Jaeg. No. 5 with +6. Papilla is distinctly visible as well as the stripe above it, and from this stripe a blood-clot projects into the vitreous. The source of this hemorrhage is a new and interesting alteration in the choroid, which certainly did not previously exist. On account of its vivid color, too, this alteration must be considered as having existed a short time only. When the patient everts his eye fully, three stripes of choroidal pigment form a triangular space

* Philip von Walther's witty definition of amaurosis as a condition where neither patient nor physician sees anything, is applicable to those cases also where there is complete hemorrhage into the vitreous.

upon a pink background, over which some retinal vessels are seen to pass. These stripes reach from the optic disk to the periphery of the fundus, as far as it can be seen through a moderately dilated pupil. Mar. 27th.—Left, Jaeg. No. 1 with +6. Right, Jaeg. No. 12 with +6. In June, *status idem.*

In the two foregoing cases the choroiditis was congenital and hereditary, but it was in no way identical with that of the father. I shall now relate a case in which both father and daughter had precisely the same form of choroiditis, that of the daughter being doubtless congenital.

Case 3.—*A.* Mr. B., merchant, middle aged, presented himself March 7th, 1871. Has been suffering for several years, but has no previous history to account for his trouble. Syphilis is denied, and there are no traces of it present.

The trouble had been increasing slowly, mostly in the *left* side, which was totally blind, while with the *right* he is able to continue his occupation. *Von Graefe*, and quite a number of his assistants, had been unable to arrest the disease of his eyes as well as relieve hemorrhoids, which the patient supposed to be connected with his eye disease. The following is the result of an examination made on the 14th of May, 1870, by *Dr. Leber*:—

Right. Snellen No. 5 easily, No. 3 with difficulty, and some words of No. 2 at 4″ without a glass. Field of vision indistinct below, less indistinct inward, and not impaired either outward or upward.

Left. Counts fingers in $1\frac{1}{2}'$ and sees movements of hand in all directions.

Patient comes on account of an aggravation of symptoms. Functional examination shows: *right*, reads Jaeg. No. 9 at 4″, field same as above; *left*, only quantitative perception of light. Physical examination discloses the following: first, remnants of iritis shown as thin synechiæ; second, choroiditis diffusa, with large patches of pigment as well as light spots seen over the whole fundus. Pigment is also distinctly seen lying upon the retina, which with the optic nerve is atro-

phic. Vessels are distinctly seen. Papilla pale, and borders ill defined. Constipation is now very annoying.

Treatment consisted in dietetic rules, aperients, and leeches ad anum, atropine and small doses of mercury, under which treatment the *left* eye returned to its former condition when examined last year.

On the 20th of August, read Jaeg. No. 5 and some words of No. 3 at 4″. Visual field was very much contracted, and it appeared to patient as if he looked through a small hole.

B. His daughter, Meta, 18 years of age, suffers from blepharitis ciliaris, and upon examination of sight, *right* eye was found highly amblyopic. Upon being questioned she stated that the weakness of sight and the changes in the eye had already been detected by her family physician, unsuccessfully treated by *Von Graefe*, *Schelske*, and *Leber*. Functional examination shows *left* eye myopic, but capable of reading Jaeg. No. 1 with ease, with *right* she reads letters of No. 20 with difficulty, and counts fingers at 3′. There is no eccentric impairment of visual field.

The ophthalmoscope shows extensive changes, similar to those of her father: large patches of pigment, almost confluent, covering the greater part of the fundus. At the periphery are several smaller round patches of different shape and color, but similar to those found in *choroiditis areolaris*. Pigment in the retina covering the vessels can be distinctly seen.

No treatment was applicable to this condition.

II. Choroiditis Specifica.

It has been long known to most observers that many forms of choroiditis are of syphilitic origin, but to this source some have attached too much importance, whilst, on the other hand, others have underrated it. Literature contains but a few definite statements concerning this form of disease.

Von Graefe considers that form of *choroiditis disseminata* which is characterized by numerous white circumscribed patches surrounded by red zones, and

occurring in the posterior pole of the globe, as chiefly dependent upon syphilis.

Soelberg-Wells says, "I have also found this form of choroiditis more frequently associated with syphilis than any other, but yet it must be admitted that syphilis may assume the most varying appearances. Thus I have seen cases of syphilitic choroiditis in which a large bluish-gray exudation occupied the region of the yellow spot, and around this, to a considerable distance, were scattered numerous smaller patches of exudation."

Liebreich, in his Qphthalmoscopic Atlas, table IV., fig. 2, gives an excellent picture of atrophy of the retina in connection with choroiditis disseminata, and is of the opinion that choroiditis specifica is distinguished by small white shining patches surrounded by dark borders, with no tendency to coalesce.

Galezowski, in his paper on "Syphilitic Amblyopia and Amaurosis,"* describes one form with large black and white patches as "choroidite syphilitique disséminée," and says that in other subacute forms appearing with pain and circumcorneal injection there are numerous red patches with complete or incomplete pigment zones and white atrophic patches. "*Des taches nombreuses*, ROSÉES, *se forment sur plusieurs endroits de la choroide, et à côté d'elles on remarque des amas pigmentaires en forme de ronds ou de cercles noirs, ainsi que des plaques* BLANCHES *de l'atrophie choroidienne.*"

Under the name "*choroido-rétinite syphilitique sans ou avec pigmentation*," he comprises the following symptoms:

* Archives Générales de Médecine, 1871.

1. "*Trouble ou perte de la vue arrivant par accès ou crises.*"

These attacks occur at varying intervals, leaving a haziness or cloudiness of vision.

2. *Nuage sous forme de toile d'araignée flottant constamment devant les yeux.*

3. *Photopsies très fréquentes.*

4. *Photophobie.*

5. *Héméralopie*, in the more advanced stages.

6. Concentric impairment of visual field, while central vision remains for a long time preserved.

7. "*Un des signes les plus constants : le trouble des milieux du fond de l'œil, qui fait voir la papille du nerf optique très nuageuse.*"

8. Atrophy of the vessels beginning at the periphery while the reddish color of the papilla is retained (in contradistinction to atrophy).

9. Retinitis pigmentosa at a later period of the disease (syphilis), mostly between six months and three years after infection. Sometimes (in 3 out of 63 cases) he found "*des taches blanches, rondes, disséminées çà et là, qui ne sont autres que des exsudations condylomateuses.*"

He considers *congenital retinitis pigmentosa* and *retinitis pigmentosa syphilitica* as identical, except that in the latter form the patches are of more varied hues. "*Les taches pigmentaires syphilitiques se déposent le long des vaisseaux rétiniens, mais elles forment des amas circulaires, circinés, en forme de cercles d'herpès circiné.*"

Many authors lay great stress upon the location of

the changes in the choroid. Some consider those forms where the exudations occur in the posterior hemisphere in the vicinity of the macula lutea, so-called *choroiditis postica*, of a specific nature, whilst others, for instance *Mauthner*, consider it specific where there are numerous small patches in the region of the equator.

According to *Schweigger*, choroiditis syphilitica is characterized by very small, punctate, red, white, and black patches in the fundus, and he also adds, it will always be necessary to base the diagnosis not only upon the ophthalmoscopic appearances, but to prove the presence of syphilis by other means.

We think also that it is impossible to make the diagnosis of specific choroiditis by the ophthalmoscopic examination alone. Here as elsewhere, for instance in specific iritis, the law found by *Virchow* holds good, that syphilis gives rise to simple products of irritation as well as pathognomonic (gum-like) products.

In general, it is more important to notice the initial than the terminal alterations of choroiditis. We shall endeavor to illustrate by a few cases some of the more frequent forms of *choroiditis specifica*, and try to show how it can, with certainty, be diagnosed.

Case 1.—Mr. L. M., æt. 37, came to the clinic December 31st, 1870, on account of his left eye. The history, as given by his family physician, showed that four months previously he had an indurated ulcer upon the prepuce, followed seven weeks later by roseola, pharyngeal catarrh, and other unmistakable signs of syphilis. The treatment consisted in sublimate pills and Zittmann's decoction. During the last four weeks the sight of the *left* eye, which had been weak for

four years, has been getting worse. Photographs taken in former years showed that he then had divergent squint of the *left* eye. For the last nine days his sight has become worse, and he is troubled with coruscations. He was ordered iodide of potassium, extractions of blood with Heurteloup and a sparing diet.

Status præsens. Patient is robust, but shows marked symptoms of syphilis; mucous patches at the angles of his mouth, and a copper-colored syphilide upon the back of his neck. No albumen in urine. With the *left* eye he can only count fingers when held very close, and most readily when held near the outer half of the visual field. With the *right* he reads Jaeg. No. 1 with the aid of +40, and counts fingers, though with difficulty, in all parts of visual field.

The ophthalmoscopic examination shows a diffuse opacity of the left retina extending from the pale, opaque papilla, the vessels of which are veiled, to the periphery, where small patches can be seen in the choroid. The right retina appears unchanged in the centre as well as at the papilla, but at the periphery are numerous small and very delicate white atrophic patches. The patient was told that his right and seemingly good eye was in danger, and was accordingly admitted to the house and placed under our usual anti-syphilitic treatment (Sigmund's inunction: ℈i. to ʒi. of blue ointment twice a day). At the same time a Heurteloup to left temple and rest in the dark were ordered. On January 7th, he unfortunately left on account of a severe attack of nostalgia. His sight was tried, and he read Jaeg. No. 1 with +36 with right eye, and with left counted fingers at $2\frac{1}{2}'$.

At home he employed a diaphoretic treatment, and on the 14th asked to be seen on account of his *right* eye, which had become worse. He said his *left* eye had greatly improved, but the coruscations before his *right* eye were very annoying, causing him to see all objects as if through a sieve or railing, or as if the sun was shining through dense foliage. He was examined by lamp-light, and with the *left* eye counted fingers at 6′, and with the *right* read Jaeg. No. 12 with +6.

In indirect vision he saw the fingers everywhere, but noticed many small isolated defects in the visual field, the largest of which was situated downward and outward.

The *left* papilla is found less veiled, but still pale, and the vessels are seen more distinctly; in the *right* eye the retina is diffusely veiled

and there is marked venous hyperæmia. In the periphery *numerous small, round, snow-white patches* are seen, chiefly following the course of the retinal vessels, around which they cluster, resembling bunches of grapes. Though, they are situated behind the larger as well as medium-sized vessels, and are but slightly raised, they implicate the retina as well as the choroid. Besides these the patches above mentioned are scattered over the whole periphery of the posterior half of the globe, the most numerous in the inner and upper quadrant, in harmony with the defect in the visual field above described.

A rigorous inunction treatment was continued for two weeks, with several abstractions of blood by means of Heurteloup's leech, the patient being always kept in the dark. An examination on the 29th of January showed considerable improvement. With the *left* eye he counted fingers at 6′.

With the *right* he read fine print, and upon superficial examination the visual field appeared complete. The opacity of the retina had cleared up, *the milky-white patches of gummy choroiditis were transformed into small round circumscribed patches with irregular pigmented borders showing a delicate pink hue when compared with the old white shining atrophic patches.*

February 12th.—Reads fine print with *right* and medium-sized with *left;* coruscations have ceased, and he counts fingers eccentrically in every direction. In the *right* eye the papilla and adjacent portions of the retina are normal, and at the periphery the above described patches are still to be seen. *Left* papilla is clear but pale, with well-defined borders. February 26th.—Reads finest print with the *right* eye, and medium-sized with the *left.* Field of both eyes complete. The retina of the *right* eye appears perfectly clear, and the patches at the periphery are most numerous, inward and upward, and here also are to be seen some rosy patches surrounded by black pigmented edges. The optic nerve and retina of *left* eye are distinct, the former being pale. Slight changes in choroid are noticed at the periphery.

The patient took pills of biniodide of mercury and iodide of potassium alternately for several months, had Heurteloup's leech now and then applied, and kept his eyes at rest. Since that time he presented himself repeatedly with excellent sight in both eyes. The coruscations have ceased entirely, he reads finest type with both eyes,

with + 6, which, for the left eye especially, is a remarkably good result.

We have seldom an opportunity of following the whole course of this disease as in the preceding instance, but I can record some cases the earlier stages of which I observed.

Case 2.—Mr. W., a young merchant, came to the clinic on account of coruscations. He is myopic, uses —10, and reads, with difficulty, Sn. No. 2 with the *right* eye, and Sn. No. 3 with the *left* at 4″. The ophthalmoscope shows: *Right*—hyperæmia of central vessels, the papilla veiled, and surrounding it, especially inward, are small, white choroidal patches. *Left*—the papilla more opaque, the opacity extending to the neighboring parts of the retina. There are also numerous stationary and floating opacities in the vitreous; many white patches lying behind the retina are spread over the whole fundus. He had an infection more than a year ago, and says he has been treated with large doses of mercury, but negligent as he was, he made his appearance only once again, and since then has not been seen.

Case 3.—Mr. D., merchant, æt. 23, came, August 12th, 1871, on account of weakness of his *left* eye. With the *left* read Jaeg. No. 8 at 6″ and Sn. LXX. at 15′, concave glasses not improving the sight. With the *right* eye read Jaeg. No. 1 at 8″, Sn. XL. at 15′, with —24, and Sn. XX. at 15′. Interior normal.

In the left are floating opacities in the vitreous, there is a slight diffuse opacity radiating from the papilla, and at the periphery are numerous small, distinct, white patches of various sizes, apparently of long standing, but without pigmented borders. They show no tendency to coalesce like similar patches in simple as well as tuberculous choroiditis, although in places they lie very close together.

The *history* is: He had an ulcer upon the genital organs six years ago, eruption over body and enlargement of the glands. He was told the cause of his eye-disease and the proper treatment; nevertheless he did not return until Oct. 17th. Meanwhile he had been placed upon an expectant treatment by a physician, who said his eye-disease was not of a syphilitic nature; but the left eye becoming worse, our patient

lost faith and returned. October 17th.—*Right* eye the same as when previously examined. With *left* can hardly count fingers when held close by. Ophthalmoscopic appearance the same as when first examined, infiltration of retina more pronounced, and papilla looks paler. (Compare Case 1.)

Inunction was persistently employed, and marked improvement ensued.

November 7th.—Reads Jaeg. No. 5 with the *left* eye, field complete. There are still delicate membranes in the vitreous, infiltration of the retina, and gummata of the choroid. The after-treatment consisted of pills of corrosive sublimate, iodide of potassium, Heurteloup and seton. Patient did not rest his eyes as directed, and consequently there was a relapse, January, 1872, so that he could only count fingers at the distance of a few feet. Inunction was repeated with benefit.

Case 4.—Anna K., æt. 33, presented herself March 13th, 1871, on account of weakness of sight and glimmering. With +6 she could read Sn. 11 in 4″ with the *right* eye and Sn. 3 at 4″ with the *left*.

In the *right* eye are remnants of iritis, from which she had suffered a few months previously. Floating opacities in the vitreous, diffuse dense infiltration of the retina, and small, punctate, roundish, gray patches at the periphery of the choroid. In the *left* eye there are neither opacities in the vitreous, nor infiltration in the retina, nor small choroidal patches. Atropine was instilled into right eye, and inunctions commenced. April 20th.—She could, with +6, read, *left*, Sn. 2, *right*, Sn. 5. June 21st.—*Left*, Sn. 2 at 12″ with difficulty without lens, *right*, with +6, Sn. 19. June 28th.—*Left*, status idem, *right*, with +6, Sn. 14 with difficulty. July 6th.—*Left*, status idem, *right*, with +6, Sn. 11 with difficulty. Iodide of potassium now used, with abstractions of blood by Heurteloup, all of which treatment improved her sight. July 19th.—*Left*, Sn. 2 at 12″ without any glass, *right*, with +6, Sn. 6 at 4″. August 11th.—*Left*, status idem, *right*, with +6, Sn. 8 with difficulty. Ophthalmoscopic appearances the same. Sublimate pills given. August 18th.—*Left*, status idem, *right*, with +6, some small words of Sn. 6. September 19th.—*Left*, status idem, *right*, with +6, Sn. 11. October 11th.—*Left*, status idem, *right*, with +6, Sn. 8, and letters of Sn. 5. November 2d.—*Left*, status idem, *right*, with +6, Sn. 11, Sn. 6, and small words of Sn. 5.

The most frequent form of choroiditis specifica is that which shows small non-coalescent patches, having the maximum size of a pea.

Their color, depending altogether upon the stage of the disease, varies from a delicate white or rosy hue to a snow white. They may be completely or only partially surrounded by pigment zones. The retina is always implicated. The papilla is veiled, and the adjacent retina opaque and swollen, especially along the course of the vessels, so that the disease may fairly be called *chorio-retinitis.* The vitreous body manifests its participation by delicate flaky or membranous opacities. In some cases the anterior portion of the uveal tract participates in the inflammation, and iritis, with formation of posterior synechiæ, supervenes.

The *nature* of the disease is chronic, and relapses are frequent. Its *prognosis* appears more favorable than in the non-specific variety. To trace its course and termination, and give an accurate description of its different stages and their treatment, a larger number of cases should be at our disposal.

The *treatment* must be anti-specific: Inunctions in the acute stage, followed by sublimate and iodide of potassium; restriction of diet, with occasional abstractions of blood by Heurteloup's artificial leech; complete rest of the eyes.

SARCOMA OF THE IRIS.

By Dr. ARGYLL ROBERTSON, of Edinburgh.

and

Dr. H. KNAPP, of New York.*

(See Table D.)

Catherine Pow, aged 24 years, was admitted to the Ophthalmic wards of the Royal Infirmary, Edinburgh, on June 29th, 1871. She states that she enjoyed good health, and did not notice anything peculiar in her sight or eyes till 14 months ago, when she had a slight inflammation in the right eye, unattended by pain, and only of short duration. At that time she also noticed that the gas-flame appeared red when both eyes were open, but she did not test the eyes separately; in other respects she did not then notice any alteration in vision. Six months later she had severe pain in the right eyebrow and temple, increased by exercise, and during night, and attended by dimness of vision whenever she attempted reading or sewing. These attacks of pain lasted for two or three weeks. About six months ago she had a slight inflammation in her left eye (apparently conjunctival), and her medical adviser directed it to be bound up, when she for the first time noticed that her vision in the right eye was very dim, so that she could not see to guide herself with it. She also noticed that the right pupil was larger than the left, and that when the left eye was closed the gas-flame appeared red, and that the light of the sun was of a yellow tint. She never experienced any photopsiæ or muscæ before the eyes. During the last two months she has suffered from pricking pains in the right eye during the night, at intervals of three or four nights, but which are not so severe as to prevent sleep. The family history is good.

Towards the end of April, 1871, she first applied to me for advice.

* The history of this remarkable case is by Dr. A. R., the description of the specimen by Dr. H. K.

I then observed that the right pupil was more dilated than the left and acted very sluggishly under the influence of light, that there was a grayish reflection from the pupil, that the right iris was somewhat discolored, and that at *its upper and outer ciliary margin there was a small light-brown tumor about* 1‴ *in length and* ½‴ *in breadth.* Vision was restricted to the counting of fingers held close before the eye. There was distinct glaucomatous cupping of the optic nerve, but no retinal pulsation visible. The tension also was markedly increased. From the very small size of the tumor of the iris, I thought that the glaucomatous symptoms might be idiopathic and not due to its growth, and I therefore recommended the performance of an iridectomy. The patient, however, would not submit to the operation, and went home to the country.

State on admission, two months later. The patient is a healthy-looking, moderately robust young woman, of light complexion.

Left eye. Iris bluish gray, pupil active and of medium size. Vision normal (V. = $\frac{20}{20}$); tension normal. On ophthalmoscopic examination, *physiological* cupping of the optic nerve is observed, occupying about half of the diameter of the disk. The disk itself is slightly oval—the fundus in other respects quite natural.

Right eye. The iris is of a somewhat darker hue than the left (slate-colored). The pupil, which has just been dilated by atropine (but which was previously observed to be larger than the left and immovable), measures 3½′′ in diameter. In the upper and outer part of the iris and at its junction with the ciliary ligament is an oval, brownish tumor measuring 1¾‴ in length by 1‴ in breadth, and extending downwards from this tumor, keeping to the ciliary margin of the iris, there is a chain of three other similar tumors of very small size (about ½‴ in diameter). A plexus of subconjunctival veins extends from near the margin of the cornea towards the periphery. These become much injected after slight pressure on the eye. The patient can, I believe, distinguish bright light from darkness, but her statements were so contradictory that it was difficult to arrive at a correct conclusion. The tension of the eye is very markedly increased (T + 2). The ophthalmoscope revealed deep glaucomatous cupping of the optic nerve, with pulsation in the central retinal artery. In other respects the fundus appeared perfectly healthy. No tenderness was exhibited on pres-

sure over different parts of the eye. Neither oblique illumination nor ophthalmoscopic examination revealed any affection of the most peripheral portions of the choroid.

From the increase in size of the original tumor and the development of several new growths, the case was viewed as one of melanotic sarcoma inducing glaucomatous symptoms. Dr. Knapp, of New York, who kindly examined the case, was of the same opinion. The patient was urged to submit to the removal of the eye without delay, to which she consented after having obtained the permission of her parents.

The eye was removed on July 4th, by the usual method. The cut extremity of the nerve presenting a dark color, an additional small piece of nerve was removed. About five minutes after removal, on placing the eye into a bottle containing Müller's fluid, I observed that the previously dilated pupil had contracted to medium size, and ten minutes later, on looking at it in the fluid, I observed the pupil to be much contracted. The eye and portion of nerve removed were set aside for transmission to Dr. Knapp for examination.

On July 8th the conjunctival wound was completely healed, and the patient left the Infirmary (the suture was removed the day before).

I saw the patient in April, 1873. She appeared in excellent health, and the contents of the orbit were free from disease. She wore an artificial eye. I had a letter from her in June, 1873, that is, two years after the operation, in which she stated that she continued in good health, and there were no signs of any return of the disease.

Anatomical Examination.

The eye, perfectly hardened, was opened by a circular section in the equatorial plane. The coagulated vitreous showed under the microscope a finely-dotted and striated basis-substance, in which there were embedded small cells with distinct nuclei surrounded by protoplasm branching in irregular offsets—amœboid cells; furthermore, large stellate cells anastomosing with one another

—fixed cells; and long curved threads and bands which had irregular outlines and were studded with black dots. This condition is the anatomical expression of what is ophthalmoscopically diagnosticated as "diffuse and formed opacities of the vitreous body." After careful removal of the gelatinized vitreous humor, the inner surface of the posterior half of the globe—the fundus oculi—disclosed a marked cup-like depression at the entrance of the optic nerve—glaucomatous excavation—but no other abnormity. The anterior parts of the walls of the vitreous chamber, viz., ciliary body, supensory ligament, and posterior capsule of the lens, were likewise normal. I then detached the ciliary body, iris, and lens from the sclerotic, in order to obtain an unobstructed view of the front surface of the iris, the outer surface of the ciliary ligament, and the pars non plicata of the ciliary processes (Fig. 1, Tab. D). The front surface of the iris was dull, grayish-blue. On it were seen a great number of minute roundish elevations (Fig. 1, *a*), two or three somewhat larger nodules (*b*), and a brownish hemispherical tumor the size of a pea (*c*), situated at a small distance from the insertion of the iris. Looked at with a low power of the microscope by incident light, the elevations and intumescences dissolved into clusters of small roundish or irregular nodules, with a yellowish, glassy-looking, and granular surface (Fig. 2, *a*). Near the inner boundary of the larger iris-zone the same substance was more diffusely spread over the anterior face of the iris (Fig. 2, *b c*). The surface of the larger tumor (Fig. 1, *c*) was somewhat uneven and finely granular.

Transverse sections of the iris (Fig. 3, Tab. D), when

examined with a low magnifying power, showed the posterior (*p*) (uveal) and middle (*m*) (stroma) layers unchanged, but the anterior layer (*a*) thickened, and studded with small oblong (*d*) and round (*b*) tumors. The sphincter pupillæ muscle (*s*) was normal. The tumors were the clusters and diffuse thickening which we observed on examining the front surface of the iris by incident light (Fig. 2). Sections through the centre of the larger tumor (Fig. 4, Tab. D), disclosed a uniform, cellular, extremely vascular texture in immediate connection with the uvea. Numerous pigment-cells were seen in some portions of the tumor (*p*). Sections through the periphery of the large tumor showed a thickening of the anterior layer of the iris like that which we have noticed in the small nodules.

The structure of all the tumors, when examined with high powers, consisted of densely crowded small cells or nuclei surrounded by scant protoplasm, embedded in a homogeneous matrix (Figs. 5, 6, 7: the cluster of cells on Tab. D, designated Fig. 6 $\frac{800}{1}$, should be Fig. 5 $\frac{800}{1}$). The cells were finely granular and had distinct, shining nucleoli. At the edges of thin preparations (Fig. 6, *a*) many cells were spindle-shaped, but where they lay more densely above one another (Fig. 5, and Fig. 6, *b*), only the round and oval forms of the nuclei were conspicuous. I should state that the round cellular elements were prevalent on the edges as well as throughout the whole extent of the majority of the preparations, however thin they were made. The neoplastic elementary parts, in most places, were separated from the stroma of the iris by an ill-defined line of demar-

cation (*c*, Fig. 6), but where they formed larger tumors (Fig. 4), the middle layer of the iris had disappeared, and the pseudoplasm was in immediate contact with the pigment stratum. The stroma of the iris was normal in many places; in others, however, more or less infiltrated with and replaced by nuclei and small cells, resembling those of the pseudoplasm. The *blood-vessels* of the tumor (Fig. 4, *v*) were not only very numerous, but uncommonly large. They anastomosed freely. Their walls were thin and delicate (Fig. 7, *v*), consisting only of one homogeneous, transparent layer. It was not possible to distinguish between arteries, veins, and capillaries. The *pigment*, which was exceedingly scant in the smaller nodules, but conspicuous in some places of the larger tumor, was found in isolated granules (Fig. 6, *g*), in clusters of small disks (Fig. 7, *d*), and in round or irregular forms (Fig. 7, *e*). Apart from the iris, all the other coats of the eye were found normal.

As to the *nature* of the disease exhibited by the specimen under consideration, we cannot hesitate to pronounce it a *melanotic sarcoma of the iris*. Not mentioning the rarity of such tumors in general, the case above described shows some features of particular interest, especially the development of the pseudoplasm from the anterior layer of the iris, and the great number of small tumors. The anterior layer of the iris consists of a matrix of fine connective-tissue fibres in which numerous nuclei and cells are embedded. A single layer of epithelial cells covers this stratum in children, but is absent in the adult. The front surface of the iris is lined by a dense and very delicate network of connective tissue.

I take this description from J. HENLE's text-book of anatomy, because it corresponds with what I have seen myself, but should not forget to mention that G. SCHWALBE states that the anterior epithelium ("endothelium of the anterior surface of the iris") is of constant occurrence. The pseudoplasms in the specimen under consideration not only originated in this anterior layer of the iris, but had a very similar structure. They may, therefore, be considered as homologous formations. The scant and delicate intercellular substance, the dense accumulation of the nuclei and round cells, and their development into spindle-shaped formations, characterize the nature of the growth as sarcomatous.

The question is whether the single isolated tumors were the result of a common morbid tendency in this iris, or the product of dissemination from the primary (larger) tumor? The location of the larger tumor in the upper part of the iris and the denser accumulation of the smaller tumors in the lower part seem to support the dissemination hypothesis. Small particles of the larger tumor may have been detached, suspended in the aqueous humor, and, by gravitation, settled upon the lower part of the iris. This process would be analogous to the punctate depositions on the walls of the anterior chamber in serous iritis. I examined the posterior face of the cornea and the anterior capsule of the lens, but found them free from depositions. Though this seems to be an argument against the propagation of the pseudoplasm by dissemination, it does not positively exclude it, for it seems natural that elementary parts of the type of connective tissue, when sown on

different organs, may take root in a tissue of the same nature, whereas they may perish on a heterologous tissue.

To what cause the primary tumor owed its origin cannot be ascertained. That a propagation by uninterrupted lateral extension took place in our specimen, is demonstrated by the diffuse accumulation of the pseudoplasm near the minor zone of the iris.

The former view, that a morbid tendency towards the generation of this neoplasm may have existed in the iris, is not without analogy either, for isolated melanotic tumors are sometimes observed over the whole body. A few years ago I saw such a case, which was under the care of Dr. *F. Simrock*, of New York. Melanotic sarcomatous tumors were scattered over the whole skin of the patient; besides, they were found in the iris and choroid of both eyes, and in the parenchymatous organs when the patient died. Which of these two views has the greater probability, I am unable to tell.

There is only one case of melano-sarcoma of the iris on record (Arch. f. Ophthalm., Bd. XIV. No. 3, p. 285, etc.). It was that of a farmer, 38 years of age, who in May, 1868, came under the care of Prof. *A. von Graefe.* The lower half of the iris was occupied by a brown tumor, which in the course of a year had developed from a congenital brown speck in the iris. S. normal; F. complete. Von Graefe diagnosticated a malignant growth, and removed the eye. The specimen was examined and described (*l. c.*) by *F. Hirschberg.* It was a very vascular spindle-celled melano-sarcoma, starting probably from the anterior layers of

the iris, as healthy iris-stroma was situated behind the peripheric portions of the tumor.

The case of Dr. *A. Robertson* differs from that of Von Graefe essentially: there were many small tumors, and the eye had become glaucomatous, which shows that the tumors of the iris follow the same clinical course as those of the ciliary body, choroid, and retina, viz., no irritation in the first stage, glaucoma in the second.

The growth was malignant, showing a multitude of smaller tumors, all ill-defined and consisting of a dense agglomeration of small cells with very scant intercellular substance, besides their being well supplied with large thin-walled blood-vessels.

Removal of the whole iris—which is not a difficult or hazardous operation—might have been sufficient in this case, since all the other coats of the eye were found healthy. Yet this could not have been determined prior to the enucleation of the globe, which operation was so much the more justifiable as the eye had already been blind.

The *prognosis quoad vitam* was considered favorable, as the disease, though malignant in its nature, was still limited. The freedom from a local relapse and from affections of remote organs up to this time, two years after the operation, seems to confirm this view.

INTRA-OCULAR HEMORRHAGE WITH FORMATION OF AMYLOID BODIES IN THE EXTRAVASATED BLOOD AND AMYLOID DEGENERATION OF THE CHOROIDAL ARTERIES.

By H. KNAPP.

(See Figs. 2—5, Tab. E.)

Mr. Augustus S., 42 years of age, consulted me on 31st October, 1872. He said that a few days previously, after a night passed in gay society, with dancing, drinking, and smoking, he first noticed slight uneasiness and nearly total loss of sight in his left eye. As it had not changed, he came for advice. I found the tension of both eyes normal, in the right H. $=\frac{1}{8}$; S. $\frac{20}{30}$; fundus, etc., normal. In the left there was slight circumcorneal injection, the iris discolored, the pupil dull. With the ophthalmoscope only the upper inner portion of the fundus could be illuminated; the remainder appeared completely dark. With oblique light the lens proved to be transparent, the vitreous chamber showed no details, except a reddish reflex in its lowest part. He saw only movements of the hand in the lower-outer part of the field of vision. The patient was pale, but hearty and strong. I diagnosticated intra-ocular hemorrhage, ordered leeches to the temple, rest in bed, atropine instillations, and the so-called hemorrhoidal powder (rheum, cremor tartari, magnesia carb., flor. sulph. and sugar). The circumcorneal injection and faint tenderness soon disappeared, but his sight diminished, so that movements of the hand were seen only in the centre of the visual field, whereas a candle was seen throughout. Four weeks after I first saw him, the tension of the eyeball was still normal, the light of a candle was perceived in all parts of the visual field, there was no irritation in the eye. Examined with oblique light, the vitreous chamber showed everywhere a dirty brown reflex, as if it were completely

filled with a dark-brown substance which reached as far as the posterior capsule of the lens. Its color was uniform; no blood-vessels or details of any kind could be detected. It was as if one looked into a thick, dark-brown mist.

The *diagnosis* of this case embarrassed me. After a night passed in merry-making, one eye, which had never before been thought to be diseased or deficient in sight, was almost totally blind, somewhat painful, and slightly inflamed. The dark appearance of the fundus on ophthalmoscopic examination rendered the existence of hemorrhage into the vitreous chamber probable, and the red mass, seen at the bottom of the vitreous by oblique illumination, made it certain. The course of the disease seemed, however, to differ from that of simple hemorrhage. Instead of clearing up while the symptoms of irritation disappeared, it became darker and assumed a blackish-brown color. I thought that a melanotic tumor was at the bottom of the difficulty, and that the excitement of a restless night had caused the hemorrhage, which is known to be a frequent occurrence during the growth of intra-ocular sarcomata. The absence of increased tension in the eyeball, and the preservation of faint perception of light in all parts of the visual field, on the other hand, made me strongly doubt the correctness of my supposition. The tumor, indeed, might have been situated in the ciliary region, and thus occasioned no defect in the visual field; but ciliary sarcomata hardly ever escape being detected when examined with concentrated light, and I was unable to discover any traces of such a tumor. If situated in the choroid proper, the pseudoplasm might

have been so small, and the retina have preserved its natural position and integrity so well, that perception of light was still possible. Even if that portion of the retina which covered the tumor had lost its faculty of perception, it was possible to imagine that the opacities in the vitreous body diffused the light so as to hinder the detection of a limited defect in the visual field. A detachment of the retina, on account of the preserved perception of light, had to be excluded; but we know that in the early stage of choroidal sarcomata the retina, as a rule, is not detached. In spite of this reasoning, the absence of positive symptoms of a tumor impressed me with so much doubt in regard to the diagnosis, that I requested the patient to have his eye examined by some other eye-surgeons.

He consulted Drs. H. D. Noyes and H. Althof. Both diagnosticated a melanotic tumor, and advised the removal of the eye without delay.

Supported by their opinions, I enucleated the eye, Dec. 2, 1872, nearly five weeks after it had become affected. The operation and healing were without accident.

I opened the eyeball, by a meridional section, immediately after its removal. The whole vitreous space was filled with a very soft, perfectly black mass, which, at first sight, impressed me with the idea that the disease was a melanotic pseudoplasm of very soft consistence. Originating in the choroid, it might have perforated that membrane and the retina, and proliferated in the vitreous chamber until it filled it completely. I laid the specimen in Müller's fluid. When it was hardened, a careful examination disclosed an *entirely different dis-*

ease. The soft contents of the vitreous chamber had shrunk considerably; the retina and choroid were everywhere in their normal positions, and no trace of a tumor was found. Between the choroid and sclerotic were seen collections of a dark-red, almost black substance of a granular appearance. It could readily be broken up with a probe, and resembled an old accumulation of blood, a supposition which was confirmed by the microscope. Similar but smaller accumulations were found between the choroid and retina. The blackish substance in the vitreous chamber was more coherent, yet so friable that only small pieces of it could be taken up with the forceps. Under the microscope they consisted of red blood-corpuscles and round, hyaline bodies, varying in size from the diameter of a white blood-cell to twice or three times as much (Fig. 2, Tab. E.). The majority of them showed no membrane, no striation, no nucleus, but were perfectly homogeneous. Some, however (*a*, Fig. 2), had a dark centre, in shape like a red blood-corpuscle, somewhat shrivelled. In some places these hyaline globules prevailed considerably over the blood-corpuscles; in others, especially in the masses between the choroid and sclerotic, they were scant, whereas the blood-corpuscles were abundant. They remained unchanged on addition of acetic acid, ether, and alcohol, but were colored intensely brown-red, like old polished mahogany wood, by tincture of iodine, which tinted the blood-corpuscles only slightly yellow. Addition of sulphuric acid rendered the hyaline globules violet. These reactions proved that they were *amyloid bodies.* Prof. N. FRIEDREICH

of Heidelberg first (1855) described their occurrence in extravasations of blood in the lungs and the tunica vaginalis scroti—hæmatocele. He had the lardaceous substance of a spleen analyzed by Prof. Kékulé, who found it identical with albumen and fibrin (see Virchow's Archives, vols. IX., X., XVI.). The amyloid formation in our case once recognized, I carefully examined the blood-vessels of the extirpated eye, and found that the arteries of the choroid gave the characteristic iodine reaction in their inner and middle coats. The capillaries were unaffected. The arteries appeared, under low magnifying power, as markedly brown-red stripes. Under a higher power the inner and middle coats only were seen red, the outer uncolored (Figs. 3 and 4, Tab. E.). The red coloring was homogeneous, but in it were seen numerous small cells which exceeded only little the size of white blood-corpuscles, and were placed in a dense row near the inner margin of the ves sel (*b*, Figs. 3 and 4, Tab. E.). The calibre of the arteries was much reduced, that of many veins (*c*, Fig. 4) considerably enlarged. The capillary layer (*d*, Fig. 4) appeared unchanged in some places; in others it was the seat of extensive hemorrhage (Fig. 5). The capillaries were distended, choked with blood, and the extravasations were proofs of their ruptures.

Lardaceous degeneration or infiltration being considered not as a local but a general disease, I examined the general health of the patient repeatedly, the last time June 21, 1873, but could not detect any abnormity. He looked healthy, was vigorous, and regular in all his functions. He never had had a syphilitic affection,

nor a malarial disease, nor suppuration of the bones, and has never been intemperate. His children are healthy. His urine appears normal, is secreted in normal quantity, and contains neither albumen nor sugar. His heart, spleen, liver, and kidneys do not show any abnormity on physical examination. His other eye is hyperopic, but has perfect sight, and appears normal on physical examination. I shall, however, watch the patient with reference to symptoms of lardaceous disease in other organs.

Clinically, this case is important. Amyloid formation in the eye has not yet been described. The sudden appearance of the affection, the darkness of the fundus on ophthalmoscopic examination, and the red lustre from the bottom of the eye on focal illumination, are sufficient for the diagnosis of hemorrhage into the vitreous chamber. If, then, instead of clearing up and showing diffuse and floating opacities in the vitreous body, the vitreous chamber appears dark, dirty brown, without any details, the dark cobweb-like opacity reaching to the posterior surface of the lens, perception of light being preserved in the whole field of vision, and the tension of the globe not, or not markedly, increased, we should exclude the presence of an intra-ocular tumor and detachment of the retina, and think of the possibility of intra-ocular hemorrhage with formation of amyloid bodies. This supposition gains in probability when some of the general symptoms or causes of amyloid disease are present: intemperance, lues, chronic suppurative affections, especially of the bones, or some cachexia from any cause.

The treatment should be according to the general health. Removal of the eyeball could only be recommended in cases of doubt. I am unable to foretell what inconveniences or bad consequences an eyeball affected with amyloid degeneration is likely to produce if left in place. Recovery of sight seems impossible.

Concerning the *pathogenesis* in this case, it appears most plausible that the lardaceous infiltration of the choroidal arteries, on account of the narrowing of their calibre and diseased condition of their walls, was the remote cause of the hemorrhage, the immediate cause being the disturbance of circulation resulting from the excitement of a night passed in excessive bodily exercise, and the free use of stimulants.

In order to detect the mode and mechanism of the hemorrhage, I examined larger portions of the choroid and found the following conditions: The walls of the arteries were thickened and their calibre was reduced by the waxy infiltration. The veins, not participating in the infiltration, were enormously dilated; some of them were filled with blood, but the majority were empty. The capillaries were distended and choked with blood, and many of them were ruptured. The hemorrhages originated nearly all in the capillary layer. The inner strata of the choroid, in many places, were densely infiltrated with blood-corpuscles, which in long streaks made their way inward between the choroid and retina and into the vitreous space. The narrowing of the arteries and the degeneration of their endothelium and the muscular coat must have offered a great resistance to the arterial current, and as a consequence

have greatly reduced the intra-vascular pressure in the capillaries and veins, the vis-a-tergo of the arterial current being exhausted by the uneven and narrowed calibre and the inelasticity of the walls of the arteries. The blood which was forced through the narrowed arterial tubes, was at once received in a multitude of comparatively wide and extremely thin-walled capillaries and wide veins. The force of the current, already greatly diminished by the resistance in the degenerated arteries, was now distributed over the immense space of the capillaries and veins of the choroid, by which it must have been reduced almost to a minimum. Stagnation was the immediate consequence. Stagnating blood must soon lose its nutritive power, on account of which the walls of the vessels become diseased, softened, and frail. If now in some veins stasis by coagulation or over-distension takes place, and the corresponding arteries continue to pour in, even never so little, blood, a rupture of the capillaries, the weakest link in the chain, must take place. The veins are then free from any intra-vascular pressure, no fresh blood being forced in. The elasticity of their walls is the only active force remaining, and its effect must be the evacuation of the contents of the venous tube towards the heart, facilitated by the aspiration of the neighboring venous vessels; in part, however, the veins may empty their blood also into the ruptured capillaries. This seems to account in a satisfactory manner for the conditions found in the case under consideration: narrowing of the arteries, engorgement and ruptures of the capillaries, hemorrhages, dilatation and emptiness of

the veins. The dilatation of the veins must have taken place when both capillaries and veins were overfilled with blood, a stage preliminary to the capillary hemorrhages.

I have yet to add that these morbid conditions extended over, and were limited to, the choroid proper. Ciliary processes, iris, and retina showed no traces of amyloid infiltration.

Bearing in mind that amyloid disease is not known to be limited to one organ, I, of course, warned the patient against all conditions which are liable to produce it and were mentioned above. We should, however, remember that lardaceous disease has hitherto been found in the dead-house only, where, of course, we can but expect to see cases in advanced and generalized conditions of this disease. If, therefore, our knowledge of the general pathology of lardaceous disease would lead us to frame an unfavorable prognosis concerning the life of our patient, we could not do it without great reserve considering the apparent limitation of the affection to the choroid of one eye, the absence of any cachexia, and the scantiness of our clinical knowledge of this disease.

GALVANO-CAUTERY IN OPHTHALMIC SURGERY.

By Dr. J. SAMELSOHN, of Cologne.

(Translated by T. R. Pooley, of New York.)

The introduction of a new method into surgical therapeutics, or the extending of one already known into new fields, is only justifiable under the following conditions:—

1. That it must, at least, answer the same purpose as these approved methods have done.

2. Its application must be as practicable as that which is already known, and which has been used with success. If a new method fulfils these two conditions, then we are not justified in discouraging the efforts which others may make for its introduction; if, however, it does more, and gives for certain cases simpler, safer, and less dangerous surgical manipulations than those hitherto known, then it becomes our duty to use all our endeavors for its propagation.

Considered from this stand-point, galvano-cautery, first systematically employed by Middeldorpf, has won a decided claim to the consideration of practitioners. During the lifetime of its advocate it was only exceptionally, and we may say as a scientific complement, employed in the clinics. Since Middeldorpf's death, however, it has gained a wider extension—as if the

generalizing tendency of the discoverer had delayed the growth of its individual germs.

To-day it has become a specialty not only in the hands of ALTHAUS, BRUNS, and others, but it is also used by many practitioners as a not unwelcome supplement to surgical appliances.

Some of the specialties, such as otology and laryngo-surgery, have adopted it, and it is therefore astonishing that the otherwise progressive specialty of ophthalmology has not become more familiar with its use. In order, therefore, to encourage a more extensive application of this method, it does not seem superfluous to publish my experience of five years in the application of this convenient agent for special ophthalmological purposes. It is not my intention to give an exhaustive explanation of the general method; this has already been done in the works of Middeldorpf, Bruns, Groh, etc. I shall only describe, in a simple and truthful manner, how and where I have tried galvano-cautery, and where it has proved to me a most welcome means of treatment after all others had failed.

The apparatus of which I make use is very simple, cheap, and easy to manage. It consists of three small zinc-carbon elements, which are connected by copper wires in the form of a chain. The glass vessels are common tumblers; the zinc cylinders of a corresponding size; the carbon plates 4½″ long, 1½″ wide, and ¼″ thick. These elements are filled by an assistant in the yard, so that the disagreeable vapors from the nitrous acid cannot enter my consultation room. Two flat copper wires connected with the elements lead from the yard across

the window-ledge into my room, and are fastened upon the ledge by rivets, and finally by clamp-screws.* The long, thin conducting copper wire, covered with india-rubber, fits into these clamp-screws, and is then connected with the handle. This handle contains a contrivance similar to the button-shaped handle described by Von Bruns† for closing and opening the current. Two wooden plates are riveted together, between which pass the copper wires with the current-breaker, admitting at any time of the discovery of the possible cause of an interruption of the current.

On each side brass tubes with thumb-screws are attached, into which fit, on one side the conductors, on the other side different connecting pieces. The latter consist of two twisted copper wires, covered with silk, flattened and perforated at one end, to which fine platina wires are fastened. The apparatus is charged and used according to the usual rules.

For such cases as we are about to describe, requiring only a transient glowing of the platina wire, the compendious apparatus just alluded to will answer every purpose. It gives enough electro-motor power, a current sufficiently constant for the short duration required, and relieves the practitioner from the painstaking care which more complicated apparatuses demand.

Let us now consider those cases in which I prefer galvano-cautery to all other means of treatment, and to

* Latterly I employ two Grenet-Stöherer elements filled with bichromate of potash and dilute sulphuric acid. The lack of constancy of this combination is no disadvantage for our purposes on account of the short duration of the current.

† V. Bruns: Die Galvano-Chirurgie, 1871, p. 34, Fig. 15.

which I apply it from the first. Here stands in the front rank—

1. *The closing of Lachrymal Fistulæ.*

The latest text-books on ophthalmology speak of the great facility with which lachrymal fistulæ, caused either by operation or spontaneous opening of a dacryocystitis suppurativa, close of themselves, or by the most simple treatment, as soon as the passage through the ductus naso-lachrymalis has become free.

Wecker goes so far as to assert,* "that every lachrymal fistula will close in the course of a few days, when we establish a wide communication between the lachrymal and the conjunctival sac, by incision of the ligamentum palpebrale internum. Observation of some years, both in clinical and private practice, has, however, taught me that in spite of perfect restoration of the communication of the lachrymal sac with the nasal duct, as well as with the canaliculis lacrymales, old fistulæ of the sac with callous edges remain open, and obstinately resist the usual methods employed to close them. Especially obstinate appear to me the so-called capillary fistulæ, the almost imperceptible openings of which give issue to a mucous fluid only after pressure on the sac. Here it seems, at first sight, as though a closure might easily be attained, and yet the usual methods of cauterizing generally fail. Even the refreshing of the whole fistulous tract, with or without the introduction of a suture, does not always succeed.

The principal cause of the difficulty of healing ap-

* Traité des Maladies des Yeux; deuxième édition, tome premier, p. 910.

pears to be, that the exterior opening of the fistula is not on a level with the interior opening, and as the neighboring sclerosed tissue does not easily give way, the canal is more or less bent.

These curves, and sometimes angles even, are caused by the inflammation and subsequent contraction of the sac, resulting in a displacement of the inner opening, usually upwards. On account of these anomalous curves of the fistula, the cautery, although it be very thin, can with difficulty be made to follow them; even if we use a fine silver probe coated with argentum nitricum, the cauterizing agent, exhausted by solution at the beginning of the canal, can have no effect upon its deeper parts, although the probe should reach them.

I have often succeeded in closing the exterior opening of the fistula for a short time, but the thin cicatrix would soon open again when a somewhat rough pressure upon the sac forced its contents into the open inner portion of the fistula.

If the canal of the fistula is wide, and has a large granulating external opening, the ordinary caustic can be more efficaciously applied throughout the entire extent of the canal. As, however, it is impossible to limit the action of the caustic to the fistulous canal, the operation may result in partial obliteration of the sac—an operation which has justly lost more and more the approbation of the profession. Galvano-cautery combines all the advantages of a thin cautery which adapts itself to all the windings of the canal, is of equal intensity everywhere, and can be accurately localized. Even the ob-

jection which at once arises, that the radiating and conducted heat may cause disagreeable inflammations in the adjacent parts, loses its force when we take into consideration the small surface of the glowing wire. In fact, I have never seen galvano-cautery followed by such phlegmons as are not infrequently met with after the use of the actual cautery.

The mode of applying galvano-cautery is as follows: After the passage through the nose has been made free, a sound, which as nearly as possible fills the duct, is introduced so as to be closely in contact with the anterior wall of the sac (usually Bowman, No. 6). Then the thin platina wire is by turning movements introduced cold through the external opening into the fistulous passage, until its point touches the sound in the lachrymal sac. As soon as, by pressing on the button of the handle, we close the chain, a slight scream of the patient, a burning smell, and the escape of hissing smoke, indicate the glowing of the wire. By removing the finger from the button which opens the chain, the wire immediately cools, and is then withdrawn. The pain ceases at once, and the removal of Bowman's probe terminates the operation.

I have never seen obliteration of the lachrymal sac following this operation. On the contrary, only after closure of the fistula a sufficient improvement of the diseased mucous membrane was obtained, as only then the blennorrheic membrane could be touched on all sides by astringents. The scar resulting from the operation is so slight, that it does not cause any eversion of the inferior lachrymal point.

After the operation of fistulæ of the lachrymal sac, naturally follows—

2. *The Operation of Obliteration of the Lachrymal Sac.*

Although this operation, to some extent, has justly fallen into disuse, in some cases it is unavoidable. In such cases Wecker * warmly recommends galvano-cautery, and I suppose that many practitioners have followed his good advice. I can entirely concur in his recommendation, but will not omit to give some short description of the instrument and the method of using it. In the first place, I think that we can do without the apparatus specially designed for this purpose by Wecker, and that the one above described will suffice.

The greatest difficulty in this operation, on the mastering of which its entire success depends, lies, as is well known, in the obliteration of the canaliculi. It seems immaterial to the success of the operation whether the conjunctival or the sacular opening of the canaliculi be closed; but the obliterating the sac is best secured, if, according to Pagenstecher, we close the whole extent of the canaliculi. The platinum galvano-cautery is the best means for accomplishing this purpose, as the wire can be introduced, through the slightly-slit lachrymal points, into the sac, and there be made glowing. Two cases in which I followed this method resulted in complete closure. If there be a fistula of the sac, it suffices to widen it somewhat, so as to be able to introduce a flat platinum wire, and then to bring

* Traité des Maladies des Yeux. Paris, 1867. Tome premier, p. 903.

it, while glowing, in contact with the whole wall. At the same time the opening is large enough to give exit to the pus and eschar. If, as is usually the case, the canaliculi are already slit, it will be better to introduce the wire through the fistula, and then by the aid of forceps to conduct it through the canaliculi into the conjunctival sac; we are then more certain to bring the caustic in contact with the inner openings of the canaliculi. I have successfully performed obliteration of the sac by this method four times.

Before deciding upon the operation, and running the risk of substituting continual lachrymation for a periodically recurring inflammation, I avail myself of an observation which did not escape the penetrating eye of *Von Graefe*, the correctness of which I have confirmed in three cases. He states that from the configuration of the face we can with probability say, before the operation, whether, after closing the canaliculi, the secretion of tears will be profuse or not. Hypersecretion of tears is less to be feared in broad, flat faces, with orbits wide apart, and but little prominence of the nose, than in narrow, sharply-cut faces. In the latter group of cases we ought only exceptionally to resort to obliteration of the sac. In order to prove the truth of this assertion, I performed a one-sided obliteration on a subject with a narrow, sharply-cut face, who suffered from dacryocystoblennorrhœa, with profuse secretion and capillary fistulæ. The lachrymation following the obliteration was so great, that the patient expressed himself satisfied with the healing of the fistula on one side, and preferred the trouble of

frequently pressing out the sac, to continually wiping away the tears.

A further application of the use of galvano-cautery consists in—

3. *The Treatment of Trichiasis and Distichiasis.*

Nearly all of the known operative procedures for combating this troublesome and, often in its consequences, disastrous condition, are directed to the curing of entropium, the very absence of which is characteristic of this form of disease.* All these methods are justifiable in complete trichiasis, whereas in partial trichiasis means so severe and uncertain in their results should scarcely be resorted to. If we watch the results of all these methods for a long time (transplantation of the hair-bulbs not even excepted), we must openly confess that relapses are not infrequent. This is mostly—and in the methods of transplantation always—due to the fact that it is impossible, without injury, to isolate and displace all the hair-bulbs which when diseased remove their matrix into the cartilage.

This difficulty is avoided only in Snellen's operation. Unfortunately, however, its results are satisfactory in the upper lid alone, where the firmness of the cartilage admits of a sufficient defect, whereas in the lower lid, in which partial trichiasis mainly occurs, its performance is considerably limited, on the one side by the thinness of the cartilage, and on the other side by the necessity of avoiding the lachrymal apparatus. Such considerations as these have caused all surgeons, from Celsus to

* Stellwag v. Carion: Lehrbuch d. Augenheilkunde. 1867. S. 468.

Herzenstein, to resort to means to prevent the false growth of the lashes by the destruction of their roots, without producing too great a loss of substance of the whole lid. The use of glowing heat for this purpose has been already indicated by Celsus,* and it was therefore quite natural to employ galvano-cautery as had been done by Middeldorpf, and recommended by Stellwag v. Carion.† This method now and then gives very good results, although the total loss of the eyelashes is no little disadvantage. Every practitioner knows what insurmountable obstacles the soft, down-like lashes are in the treatment of trichiasis, and how quickly the patient learns to pull out the stiff, firm lashes in order to get rid of the doctor; but it is these fine, down-like lashes which compel them again and again to fall into our hands. These pseudo-cilia also offer an obstacle to the lately re-introduced method of "*illaqueatio*," if that be more than an idle amusement. Celsus, at least, who begins the description of this method with "Quidam aiunt," does not believe in its success, and concludes his description with the words: "Gluten quo vinctus est pilus, resolvitum; eoque fit, ut is eo, unde vi abductus est, redeat." He asserts, moreover: "Id fieri non potest, nisi in pilo longiore, cum fere breves, eo, loco, nascantur," namely in exteriore parte palpebræ.

I have at different times tried this method of operat-

* Celsus: De medicina libri Octo, liber vii. Tenuis acus ferrea in ignem conjicienda est; deinde candens sub ipsis pilorum radicibus ab angulo immittenda est . . . . , quo fit, ut omnes pilorum radices ad ustæ emoriantur.

† Lehrbuch der Augenheilkunde. 1867. S. 476.

ing, but have found its performance relatively difficult, and its results nil. For sake of completeness, we mention Gaillard's operation of introducing a suture through the lid, by which doubtless the position of the eyelashes may be corrected, but it leaves such disfiguring scars that for cosmetic reasons its performance is limited. Such observations show that we are still in want of a satisfactory method for the cure of trichiasis, and that it appears justifiable to indicate one, which, at least for partial trichiasis, has always given me satisfactory results. I was led to this procedure by the idea which forms the basis of Snellen's operation, namely, to exercise, through a contraction of the scar in the cartilage itself, a traction upon the tissue covering it.

I sought to attain this result in the following manner: After having protected the lid with a horn-plate, I burn a hole under the roots of the falsely-growing lashes into the cartilage with a very fine galvano-cautery, and allow it to heal by suppuration. The subsequent retraction of the scar is strong enough to remove the lashes from the position which irritated the globe, without destroying them. In this way I have displaced as many as six cilia in one lid, at one sitting, without causing the patient too much pain. The result of this little operation is so excellent that I can safely recommend its imitation. But the cautery must not be applied too near the root of the lash, as the root may be destroyed, or the following scar may not exert a sufficient leverage upon the lash. To accomplish this purpose any other kinds of cautery except galvano-cautery will hardly answer, because they do not penetrate deeply enough; a glowing

needle will cool before it has entered the cartilage, while the galvano-cautery can be kept glowing at will. For partial trichiasis, I know of no method which can compare with that just described in simplicity, painlessness, and certainty of result.

4. *Blepharitis Ciliaris Ulcerosa.*

Now and then there occur cases of blepharitis, with such deep ulcerations of the borders of the lid, that cauterizing with lapis causes the patient intense pain, and gives the physician some trouble on account of the necessity of neutralizing the caustic. I have also, in such cases, preferred to use galvano-cautery, and have observed that healing is more quickly induced in consequence of the cautery penetrating more deeply, while the pain is less severe than in the application of any other form of cautery.

5. I have likewise used galvano-cautery in various *new-formations* in the vicinity of the eye, such as *small cavernous tumors, telangiectasiæ, nævi vasculosi* et *pilosi,* where I have always had an opportunity of observing the formation of a nice scar. I once destroyed in this manner a small cancroid of the inner angle of the eye, in a lady who feared the knife, but I cannot recommend it for imitation, as the eschar prevents us from accurately determining the limits of the new growth. I need not give special rules for the use of galvano-cautery in the destruction of these new-formations, as this is done according to general surgical principles, for the discussion of which these Archives are not the proper place.

Finally, I will report on a method of applying galva-

no-cautery in which, although I have only five cases to bear witness to its efficacy, the healing was so striking and lasting that I do not hesitate to report them; the cases in question have reference to the cruces ophthalmologorum, viz.:

6. *Old and Obstinate Cases of Trachoma Conjunctivæ.*

It is well known that KORN, of Breslau, was the first to practise the use of galvano-cautery for the purpose of causing absorption of trachomatous granulations by the formation of a slight eschar. Although he thought very highly of his results, I do not remember that results obtained in a similar way have ever been published. So far as I can understand Korn's deduction, he used galvano-cautery only to enhance the action of the usual caustics, and took pains not to destroy anything more than the conjunctival epithelium, which rapidly regenerates itself.

I think that I have convinced myself, by experiments on the conjunctiva of rabbits, that it is nearly impossible to obtain so slight an effect with galvano-cautery, but that the superficial papillary tissue is almost always destroyed at the same time. If I nevertheless used galvano-cautery in the treatment of trachoma I was, of course, not guided by the opinion of Korn, but by different principles, the final object of which was the partial destruction of the trachomatous new-formation. Unfortunately, in spite of many recent investigations on this subject, the clinical and anatomo-pathological notions of trachoma do not yet harmonize. Even though pathological anatomy has, perhaps, succeeded in separating

the idea of papillary trachoma (Stellwag v. Carion) from the complex of symptoms designated as trachoma, and has proved that the swelling of the papillary body is only a consecutive condition, it has hardly commenced to throw light on the nature of the *specific* degenerations of the tissue of the conjunctiva.*

Is the trachomatous degeneration a local disease of the conjunctiva, or the symptom of an existing general disease (Arlt)? Are the trachoma granules hyperplasies of a normal tissue existing in the conjunctiva (v. Graefe; Blumberg's adenoid tissue) or immigrations of foreign elements? Are the trachoma granulations a homologous or a heterologous new-formation?

A decisive answer to all of these questions, which are still veiled in darkness, can alone give us a point of departure for a rational treatment; for all efforts to solve these questions which have yet been made are so defective that they do more to prejudice a clear judgment than to enlighten it. Nothing is left for the practitioner except to treat the trachoma symptomatically; and here, doubtless, the principal point of the treatment *is the relation of the papillary body to the trachomatous infiltration.* If this relation is a favorable one, that is to say, if the papillary body still exists to such a degree as to be able to absorb the granulations by means of an increased vascularity, then the application of slightly irritating caustics is in place, and, with Celsus, Blum-

* It is just this anatomical darkness which explains that so unscientific a designation as **Τραχῶμα** (from **Τραχύνω**, to make rough, roughness) still clings to a disease, the practical significance of which would require a name that indicates certain anatomical conditions, and at the same time gives sure therapeutical indications.

berg,* and many others, I should condemn the opinion "that the object of the treatment of trachoma is to destroy the trachomatous granulations."

But in those cases which Stellwag v. Carion designates as "pure granular trachoma," in which the whole conjuctiva palpebrarum, as far as the reflexion fold, is covered by gelatinous, spawn-like granulations, and the entire conjunctiva appears pale and bloodless, the therapeutic question appears different to me. If we examine such a conjunctiva more minutely we shall find that the granules which project more or less above the level of the conjunctiva are pale and wax-like, while in the valleys, between the elevations, a somewhat varicose vessel (vein?), which bifurcates and embraces the granulation, is usually to be seen. If to such a conjunctiva as this I apply a caustic, which is already dissolved, or which dissolves itself in the conjunctiva by absorption, what will be its effect? It will first cauterize, more or less superficially, those granulations with which it comes in contact, without materially changing their vascularity; as, owing to the absence of vessels, their vegetative life is very weak. If in a favorable case a part of the caustic penetrates to the vessels in the valleys, then their walls will contract under this irritation, and their subsequent relaxation will permit a greater influx of blood.

This method of treatment, however, offers two dangers. On the one hand, a number of the vessels become obliterated by the pressure of the hyperplastic newformation, on account of which the others cannot exert

* Archiv f. Ophthalm., xv. 1869. S. 150.

an increased activity of absorption; on the other hand, we have to fear that the repeated irritation of the caustic, which by lack of strength often fails to destroy the granulations, may give rise to the very process which we intended to conquer—a multiplication of cell-elements and new crops of the morbid products. Every practitioner must have experienced this inconvenience in the treatment of gelatinous trachoma. But here the orthodox objection will be made, "that it is an unpardonable blunder to touch the trachomatous granulations with a caustic; on the contrary, only a part of the conjunctiva, especially that which contains the papillæ, ought to be slightly touched with the caustic, in order to stimulate its activity." The answer to this objection is given in the above-described form of disease, in which the vascular papillæ are so diminished in quantity, so changed in quality, and so inaccessible, that as a matter of course the application of caustics is inadmissible, as daily experience teaches us that its application is usually followed by the results above described.

If gelatinous trachoma in its advanced stage is left to itself, it may, as is well known, spontaneously end in apparent resolution. This occurs in the following manner: The trachoma granules undergo a retrogressive metamorphosis, become destroyed by shrinkage, and leave a cicatricial mucous membrane and tarsal cartilage—changes which lay the foundation for such complications as xerosis, entropium, etc.

It is obvious that two factors combine to bring about these cicatricial degenerations, *i.e.*, defects produced in the normal tissue of the conjunctiva by the granulations,

and atrophy of the vascular papillæ caused by pressure of the new growth. The object in treatment is to break, while it is still possible, this *circulus vitiosus* (as such the just-mentioned condition must appear even to the most superficial observer). I think that it is possible to meet this indication so long as complete shrinkage has not occurred, so long as a part of the papillary body still exists; and I hold that the only way to accomplish this is by a *gradual destruction of the isolated follicles.* If we succeed, for example, in causing a granule to shrink rapidly, then it is clear that the neighboring papillæ are relieved from a part of the pressure upon them, and the rest of the vascular loops become free. If the liberation of the circulation takes place slowly, through gradual destruction of the granulations, then we can *à priori* expect that the restoration of the papillary body will be brought about without too great vascular activity, and has still time to fill in the defects in the tissue. Certainly the success, that is, the initiation, of this supposed mechanical process, depends upon the fact that a granule only, and not the adjacent conjunctiva, is destroyed. No caustic hitherto employed has answered this purpose. The excision of the granulations, even by the most cautious methods, must include a part of the surrounding conjunctiva, and the stronger caustics, such as lapis in substance, or kali causticum, cannot be used in such a manner as not to affect the conjunctiva by their solution.

I believe that this fact explains the discredit into which the destruction of the granulations has fallen. I have found that galvano-cautery accomplishes remark-

ably well the isolated destruction of the new-formations. I will readily confess that it may seem strange, and that it has cost me a great effort to make for the first time, on this theoretical basis, with a white-hot platinum wire, an application to a deeply diseased conjunctiva. I believe, therefore, that I cannot better illustrate the result of this treatment than by reporting the first case which I have cured by a method presently to be described.

Miss v. B., a tall, slender blonde of 19 years, presented herself to me on the 4th of September, 1870, with granular conjunctivitis of the right eye of ten years' duration. At the time she presented herself the difficulty was not severe, but she told me that the eye was every now and then inflamed, and the vision at the same time obscured. Rather dense opacities of the cornea, to which at this time no blood-vessels ran, indicated the previous attacks of inflammation. The granular process was limited to the conjunctiva palpebrarum, and almost that part alone which covers the cartilage, the reflexion-fold being but slightly affected and showing only a few cicatrices. The tarsal parts of the conjunctiva were closely beset with gelatinous granulations, and were waxy-pale.

As a matter of course, during the ten years' duration of her eye-affection, the patient had been treated with all sorts of remedies, both external and internal, and had just passed five months in an ophthalmic institute. Without being asked, she told me at once that her eye could not bear any caustic; even the mildest applications made it worse.

She wished very much to be freed from these ever-recurring inflammations, but had given up the hope of ever using the eye again. Under these circumstances, I decided upon a cautious destruction of the isolated granulations by galvano-cautery, hoping that the good vascularity of the reflexion-fold would secure the restitution of the blood-vessels. On the first day I very slightly touched the centre of two of the most prominent granulations with a very fine platina wire, which pierced the granulation with a hissing sound, and was withdrawn cold.

The patient, who was very timid, wondered at the complete painlessness of the burning, for she still had a painful recollection of the cauterizations with cuprum and other caustics. This painlessness proved to me that the galvano-cautery had only touched the granulation, and not the conjunctival tissue proper. The reaction after this application, against my expectation, was nil. In the course of a week the two granulations had entirely shrunken, the scars were punctiform and scarcely visible, whereas the adjacent conjunctiva had become decidedly less torpid. After a week, I subjected some other granulations to the galvano-cautery treatment, and I had already become so bold as to cauterize six of them. This time also the reaction was insignificant, and the shrinking, with subsequent vascularization, went on very favorably. Every week I repeated this treatment in the same way with the best success, so that, after the lapse of four months, the patient was cured. The condition of the conjunctiva was as follows: All the granulations had disappeared, the papillary body extensively vascularized, and only here and there a small, soft scar was seen in the conjunctival tissue, whereas the cartilages showed no change in form. This favorable result, up to the hour of my writing, has not been impaired by a relapse, while the cornea in the meanwhile has cleared so far that S=½.

This result must doubtless be considered a good one, and even the greatest purist in treatment of trachoma by absorption must have his objections modified by the fact that only slight scars of the conjunctiva remained, as according to my experience a severe trachoma never ends without leaving scarry sclerosis of the conjunctiva, whatever treatment may have been resorted to. I can sincerely assert that in the case just reported the scars caused by galvano-cautery were slighter than in many cases treated by sulphate of copper.

In support of this assertion, I refer to Wecker:*

* L. c. Tome i., p. 98.

"Le prognostic sera tout autre si la conjonctive se trouve hérrissée de véritable granulations. Il ne nous sera possible alors de rendre à la muqueuse son état normal qu'après un traitement excessivement long, et nous ne pourrons que *très-rarement* remédier à la production d'une foule de cicatrices qui sont la conséquence des véritables granulations."

As this case, however, might have been only a favorable accident, I did not omit to subject the next analogous case of trachoma to a similar treatment. This occurred on Feb. 14th, 1872.

Mrs. B., of Cologne, who had heard from my patient of her cure, came to me with a chronic gelatinous trachoma of the left eye, which in spite of all treatment she had had for three years. She asked me to burn it away "according to my method." The case was more favorable than the other, in so far as the disease was of shorter duration, and during all the inflammatory attacks the cornea remained entirely clear. On the other hand, it was less favorable, as the reflexion-folds were also gelatinously infiltrated, and bulged by eversion of the lids. The result of the galvano-cautery treatment was an equally favorable one. The eye became quite cured, leaving very slight linear scars, and no deformity of the cartilage. In this case, however, the treatment lasted until August 23d.

This long duration of the treatment is explained by my applying the cautery at much longer intervals, because after an accidental absence of the patient for four weeks, I observed that the granulations last cauterized (four weeks ago), had become smaller without direct cauterization. I concluded therefore, from this observation, that the vascular loops liberated by the destruction of one granulation might, under particularly favorable circumstances, exercise an absorbing influence upon the

surrounding granulations. For this reason, I now cauterized the granulations in insulated groups, at intervals of from three to four weeks. I have also followed this method of treatment in three other cases; the duration of treatment was from three to five months. As, however, the course of these cases presents nothing of interest, either as regards a further development of the method or of any peculiar accident, I do not wish to lengthen this communication by reporting them. I am quite aware that five cases are too small a material from which to make deductions as to the usefulness of a method. Nevertheless, as this method possesses of all others the great advantage of being less painful in its application, entirely without danger, and in its termination, as regards the formation of scars, is not more objectionable than the others, besides having the advantage of a more speedy cure, and being less troublesome to the patient, I do not hesitate to submit it to the profession for their examination, while I shall not fail to publish my further experience when I have made a greater number of observations.

THE CONNECTIONS BETWEEN THE OSSICLES OF HEARING.

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(With two lithographic plates, Tables III. and IV., and two wood-cuts.)

Ever since the connections between the ossicles of hearing have been microscopically examined according to the latest improved methods, results differing from those previously obtained have been arrived at, and it is obvious, considering the minuteness and delicacy of the parts which come under consideration, that the mere macroscopic examination could not be sufficient. Up to the present time there has been a diversity of opinion on many points of the question before us, though it seems necessary that these fundamental conditions should once be cleared up.

Hitherto the connection between the hammer and the anvil, and that between the anvil and the stirrup, have been considered by all authors as true articulations, whereas the insertion of the stapes into the fenestra ovalis has been recognized to be a symphysis, and the attachment of the short process of the incus to the wall of the tympanum has been stricken from the list of articulations.

My own investigations have satisfied me that there are

no true articulations at all between the ossicles of hearing, but that the ossicles represent a lever, the parts of which are united with one another, as well as with neighboring parts, by symphyses. I demonstrated this fact* three years ago in regard to the connection between the stapes and oval window, as well as between the stapes and incus. Concerning the former, my investigations have been in perfect harmony with those made at the same time by Eysell† and Buck,‡ whereas Rüdinger§ considers it a sort of semi-articulation, because in the interposed fibrous tissue he found lacunæ filled with fluid, which I must, from what I have observed, pronounce artificial.

Even Rüdinger concedes that there is a fibrous or fibro-cartilaginous mass interposed between the articulating cartilaginous ends of the incudo-stapedial and malleo-incudal connections; which, by the way, conspicuously resemble each other. He was even the first one to point out this condition in the malleo-incudal junction, whereas he considers the interposed tissue as a meniscus which is partially adherent to the circumference of the enveloping capsule. He therefore calls these two connections double-articulations. I have, however, found that the union is complete, and that these junctions must be considered as symphyses.

My present investigations refer principally to the malleo-incudal junction.

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* Beiträge zur Anatomie und Histologie d. Mittl. Ohrs. Leipsig. 1870.

† Archiv f. Ohrenheilkunde. Bd. v., p. 237.

‡ Archives of Ophthalmology and Otology. Vol. 1, No. 2, p. 613.

§ Beiträge z. Histologie des Gehörorgans. München. 1870.

After decalcification (in alcohol, with 5 per cent. muriatic acid), I imbedded the specimens in a solution of gum-arabic. In compliance with the wishes of a colleague, I venture to give a few hints concerning this excellent though somewhat tedious method. I added about 25 drops of glycerine to a quantity of dissolved gum-arabic, of the consistency of syrup, having the volume of 30 grammes of water. When the specimen was imbedded I allowed the solution of gum-arabic to dry, so that the whole mass might be taken out of the cup and placed in ordinary or somewhat dilute alcohol, in which it lay one or several days, according to the size of the specimen, until it could be cut like cheese. When the relations of the parts are very complicated, it is well to mark the specimen before imbedding, that you may know the plane in which the sections are to be made.

Cutting the malleo-incudal junction in a plane which is nearly parallel to the upper margin of the short process and vertical to the long axis of the malleus—that is, about in the horizontal plane of the head—the following relations are shown (see Figs. 1 and 3).

The corresponding surfaces of the hammer and anvil are covered by a layer of cartilage of an average thickness of about 0.015 mm. Between these surfaces, and continuous with them, is fibrous or fibro-cartilaginous interposed tissue of about 0.030 or 0.040 mm. in diameter, which I will call ligamentous or fibro-cartilaginous disk. It is of nearly equal thickness throughout, forming a continuous layer between the two borders of the hyaline cartilage, and has its thickened circumference in immediate connection with the fixing ligament (formerly called joint-capsule). This fixing ligament consists of delicate parallel straight fibrillæ, being in some places very thick and showing a great similarity to the connecting ligament of the incudo-stapedial symphysis.

The fibro-cartilaginous disk (Rüdinger's meniscus) consists of bundles of dense connective tissue, interspersed here and there with cartilage cells, and is not affected by weak solutions of caustic potash, although containing only traces of elastic tissue. The bundles are often plaited together (see Fig. 4), but I have not succeeded in finding any constant arrangement throughout. At the junction of the fibro-cartilaginous disk with the hyaline cartilage most of the fibres run parallel to the surface of the latter, and they often disappear imperceptibly in the hyaline basis-substance, but in some places the fibres run obliquely to the boundary-surface of the hyaline cartilage, and in Fig. 4 a bundle is seen running vertically and bending abruptly near the boundary-line. The periphery of the ligamentous disk, as we have said before, has a rounded, thickened rim protruding more or less between the hyaline cartilage, and showing a somewhat different structure than the other portions of the disk. It is more glistening, contains more cartilage cells, and in horizontal sections the arrangement of the fibres appears more irregular, in some places coiled and in others reticulated. This thickened edge is in connection with the hyaline cartilage as well as with the fine straight fibrillæ of the fixing ligament, whose fine fibrillæ appear in some places to be in immediate connection and in others even interlaced with those of the disk, the line of demarcation being everywhere distinct. Concerning the occurrence of elastic fibres, the same condition is found in the thickened edge as in the disk itself.

The existence of the ligamentous disk can be easily

proved by careful preparation, and I have found it constant in twelve specimens which I have examined.* It was more difficult to ascertain its connection with the cartilage, and at first my judgment on this point vacillated for a long time, until at last I was able to convince myself of the constant occurrence of this connection.

It has been clear to me from the commencement that we have here not to deal with an ordinary joint and meniscus, as the cavity does not gap equally on the two sides of the fibro-cartilaginous disk; yet, on the other hand, it cannot be denied that the boundary between the cartilage and the disk can be often traced as a fine line (see Fig. 4), which is rendered more conspicuous by the different aspect of the two tissues, and accordingly it might be supposed that there is a true separation, and that the tissues have become shifted. To this it must be added that the calls of the hyaline cartilage become scarcer and at the same time more elongated as they approach the disk, so that at last only a thin strip of hyaline substance is left, such as we find on the articular surfaces of bones.† I have been impressed by close and repeated observations that the boundary-line is only the optical expression of the difference between the two forms of tissue. In fact, there

* This had escaped my notice when writing my former paper. As an excuse, I may say I had paid but little attention to the malleo-incudal connection, and as the greater portion of the disk was accidentally lost, it was supposed there was an ordinary joint. Being now better acquainted with the parts, I can accurately trace shreds of the disk adherent to the hyaline cartilage in those of my former specimens which I have preserved.

† We cannot expect, nor do we find, an epithelium here, as it is never seen in other joints, although, if it should be, it would simplify the question.

are places where this optical boundary is not clearly defined, and where it even seems to be interrupted, and in others *the fibres of the disk disappear gradually in the tissue of the hyaline cartilage.* By stretching the sections of the two bones asunder, either after it is in the field, or, better, before placing the specimen under the microscope, I obtained very demonstrative views, one of which—Fig. 3—I have drawn with the camera lucida. In this figure it is seen that the artificial line of separation coincides in some places with the above-mentioned optical boundary-line (*b*, in Fig. 3), but on the whole it runs through the middle of the ligamentous disk; consequently it is easier to tear the disk asunder than to separate it from the cartilage.

I must discard the idea that I had to deal with pathological adhesions, because it would have been an unusual coincidence if in all of the twelve specimens examined by me there had been a similar condition of total adhesion.

In the newly born there is a uniform, uninterrupted cartilaginous mass connecting the incus and malleus, and the future transformation of the middle layer (the ligamentous disk) is only indicated by the intenser imbibition of some of the cartilage cells with carmine, and their elongated shape, furthermore by the beginning and still indistinct striation of the matrix. The cartilage cells are seen uniformly arranged, and a sharp boundary-line of any middle layer cannot be detected.

The thickened edge here also consists of hyaline cartilage in contradistinction to the ligamentous band, which already shows the same fine fibrillæ as in the adult. Although this cannot serve as conclusive evi-

dence, from the fact that in the newly born there are many things in a rudimentary condition, it is, however, of some interest as regards the development of the malleo-incudal articulation.

In conclusion, I may remark that I have never seen a blood-vessel in the disk. The disk, no doubt, is nourished partially from the bone and partially from the periphery. In the newly born, where the middle ear is in a hyperæmic condition and all the vessels are naturally injected, I have seen capillaries running into the thickened edge, but no farther. This want of vessels may give rise to a predisposition to atrophic processes, to sclerosis and calcification of the ligamentous disk.

We shall now examine the *malleo-incudal symphysis* more closely. It can be no longer doubted that the complicated formation of the two surfaces of the bones is of fundamental importance in their mechanical function, and that their peculiar conformation has indeed the striking effect that the two bones become locked when the membrana tympani moves inward, while with the opposite movement their connection is loosened. This was first shown by Helmholtz, and is not difficult to demonstrate according to his method.* I could see this locking of the bones very distinctly in a specimen which had lain for some time in Müller's fluid. I ascribe it to the fact that the soft parts (cartilage and capsular ligament) are here better preserved than when subjected to alcohol, by which the delicate parts, on account of rapid drying, become very friable. This seems to

* L. c., p. 29.

prove that the presence of the soft parts is necessary to the above-described action of the bony surfaces. The accuracy with which the two ossicles were locked and unlocked, according to the direction given the handle, was quite remarkable.

Rüdinger * ascribes to his meniscus the function of filling the space between the two incongruous surfaces of the ossicles. But it is easy to convince ourselves, from macerated ossicles, that the complicated surface of the malleus corresponds entirely to that of the incus, and this arrangement is indispensable to the accurate locking of the bones. I cannot understand the use of a movable meniscus; it would rather facilitate the gliding of the two surfaces and embarrass the exactitude with which the slightest motions are transmitted. Although the interposed tissue does not show exactly the same diameter everywhere, nevertheless it does not interfere with the coadaptation of the two surfaces. I avail myself of this opportunity to call attention to the fact that the cogs of the hammer and anvil, when unlocking, do not slide on each other in the "frontal"—transverse—plane only, but in consequence of their screw-like shape separate in the "sagittal"—antero-posterior—plane, as is nicely shown in the model of Helmholtz. The space which is left must, from the limited action of the bones, be very small, and is filled at once by the disk, the above-described thickened edge assisting perhaps to fill the space by the pressure of the tense fixing (capsular) ligament.

It could be supposed that the interposed fibrous tissue would prevent the unlocking of the ossicles. It must be remarked that, according to Helmholtz, the amount of excursion of the malleo-incudal joint does

* He says: If we compare the curvature of the articulating surface of the hammer with that of the anvil, we must necessarily conclude that the interposed elastic tissue as above described is necessary to make the surfaces coincide, not mentioning another important physiological function of this arrangement.—*Monatsschrift für Ohrenh.* 1871, p. 112.

not reach even 5°, because the handle of the hammer, apart from the resistance offered by the symphysis, cannot depart more than ½ mm. from the long process of the incus, and the ligamentous disk will certainly admit of a corresponding degree of extension.

This is proved by the following experiment of Helmholtz.* If after severing the connection between the incus and the stapes we move the handle outward, as far as allowed by the restricting ligaments of the hammer (the ligamentum superius and part of the fibres of the ligamenta externum and anticum, as well as the tensor tympani), the long process of the incus, although following the hammer, departs from the stapes only ¼ to ½ mm. If, in this position of the hammer, the long process of the anvil is pressed against the stapes, it remains in its new position, the cogs are unlocked, and there is not sufficient force present to retract the anvil. If the incudo-stapedial joint is preserved, says Helmholtz, the end of the long process of the anvil, of course, is always joined to the stapes; but from the above-described facts it follows that when the handle is driven outward the anvil exerts no traction on the stapes. This is not absolutely correct, as the above-quoted experiment proves that the hammer in its outward movement usually takes the anvil along with it, and a certain degree of traction is necessary to loosen the connection. The cogs are not unlocked until the resistance offered by the incudo-stapedial connection to the outward movement of the long process of the anvil becomes

* Mechanik d. Gehörknöchelchen Separatabdruck, p. 36.

greater than its adhesion to the hammer. In order to hear distinctly, it is absolutely necessary that the hammer and anvil be closely connected in their to and fro movements, so that they can vibrate as a whole. If this were not the case, we could not hear tones purely, but jarring sounds would be produced. Such sounds, for instance, are heard, according to Helmholtz, when a tuning-fork of 116 vibrations is held before the ear, and which he explains as follows: "When the excursions of the membrana tympani are very great, the anvil is not driven outward with sufficient force, and cannot, therefore, perfectly follow the excursions of the hammer; the result of this will be that there will be a separation, and during the next inward vibration the anvil receives a shock from the returning hammer."

I consider it to be the particular function of the symphysis to hold the hammer and the anvil close together,* in order to avoid the clashing sounds under ordinary circumstances when the excursions are much less than those just mentioned, leaving, however, sufficient space for extraordinary cases.

Helmholtz was well aware of the close adherence of the hammer and anvil.† He says (p. 41): "It seems

* Helmholtz says (l. c., p. 40), that as long as the ossicles are firmly united the excursions of the handle are less than $\frac{1}{10}$ mm. Buck, in the above-mentioned paper, noticed excursions of the handle amounting to 0.43 mm. in maximum, while one end of an organ-pipe was hermetically connected with the ear of a cadaver by means of a glass tube; but such an intense tone could not be borne by any living ear.

† In his model of the ossicles of hearing, the hammer and the anvil are held together by a spiral spring, which is inserted in the centres of the articular surfaces, and corresponds more nearly to a symphysis than to his own description of the malleo-incudal connection, which he calls (l. c., p. 2) a freely-movable joint enveloped by a delicate, loose, capsular membrane.

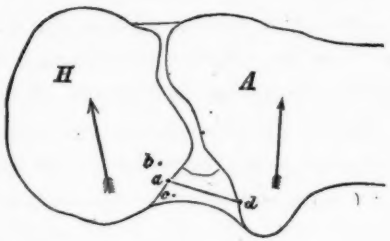
that the articulating surfaces of the hammer and of the anvil adhere to each other by friction, as this can be noticed in the anatomical specimen when the incudo-stapedial joint has been disconnected, the hammer by suction is drawn outward into the canal."

Of course, the arrangement of the fibres in the ligamentous disk is of importance in reference not only to the kind, but the degree of mobility of the ossicles. I have not yet been able to discover any constant condition, but so much at least is evident, that the fibres do not cross directly by the shortest cut, *i.e.*, they are not vertical to the plane of contact. Their arrangement, on the contrary, seems to indicate a greater motility, which again is modified by the capsular ligament.

This ligament (formerly called capsular membrane) is thickened in two places, and has not yet received due attention. It is most developed in two places; first, in the upper half of the inner side, extending as far as the cog of the anvil. To afford room for this part of the ligament, the bones separate a little, and form a depression, which can be seen by the naked eye, and is also indicated in the majority of illustrations.* Fig. 1., Tab. III., which represents a horizontal section of this region, renders it evident that such a powerful part of the ligament must be of importance, especially when compared with its slight development on the outer side. It is also seen that the fibres run obliquely to the plane of the symphysis, their insertion into the anvil lying nearer to the median line than their insertion into the

* Especially in Gruber's *Studien über das Trommelfell*, Tab. I, Fig. 2, and also in the already-cited paper of Helmholtz, Fig. 9.

hammer. The anvil at this place shows a small projection. The effect of this arrangement is obvious, and easily understood by the assistance of the accompanying figure.



Let *a d* be a fibre of the ligament which will be stretched when the head of the hammer swings outward, in the direction of the arrow (or when the handle moves inward), because the distance *b d* is greater than the distance *a d*; but if the head of the hammer goes inward (that is, the handle outward), the distance between the two points is diminished. This ligament is of further significance from the fact that the long process of the anvil somewhat approaches the handle when the handle moves inward.*

The lower part of the symphysis is then locked tight with the cogs, but the upper part would be loosened if the ligament under consideration did not

* This is because the short process of the anvil lies to the inner side of the axis of the hammer, and therefore its end is slightly elevated when the handle is drawn inward, as is easily illustrated by means of a match and two pins; but the short process of the anvil is restricted in its movements by its ligament—the anvil slides along the hammer in such a way that their two long processes approach each other.—*Helmholtz*, l. c., p. 31.

exert a great resistance, aiding, on its part, to increase the pressure.

From what has been said it follows that the ligament serves materially to strengthen the union of the ossicles. The ligament must be most developed in the upper portion of the symphysis, where it is farthest from the axis of rotation, but as it extends to the middle, it secures a still firmer union.

The opposite pole of the symphysis—as I have remarked above—that is, the lower half, or rather the lower third, of its outer side, in the region of the cog of the hammer, is the *second* place where the capsular ligament is strongly developed, as is also stated by Helmholtz.* This part gives the lower portion of the symphysis the firmness necessary for the closer fitting of the cogs, and protects the symphysis from too forcible an extension and consequent rupture. As this ligament is situated near the axis of rotation, it is not affected by the sliding of the hammer on the anvil in the frontal plane, but it is to be remarked that there is a bundle of fibres which arises from the middle of the ligament, and passes to the opposite wall of the tympanum, in a direction vertical to that of the fibres of the ligament. This fibre-bundle, together with the ligament, will be put on the stretch as often as this part of the ossicles is drawn inward. Furthermore, as the

* He says, l. c., p. 29: The periphery of the articulating surfaces is connected by a capsular ligament, which is inserted into grooves encircling the articulation. The capsular ligament is not very strong, and is easily broken even by slight traction upon the bones. Its firmest part are the fibres that spring from the cog of the hammer; from here also several fibres of the ligamentum externum of the hammer pass over to the anvil.

corresponding surfaces, in consequence of their screw-like form, not only slide on each other in the frontal plane, but separate to a certain degree when the cogs are loosened, this and the other portions of the capsular (fixing) ligament serve to restrain the separation of the articular surfaces.

Tympano-incudal connection.—Fig. 1 represents a horizontal section of this connection, to which I have again satisfied myself that the end of the processus brevis of the anvil is covered with a thin layer of cartilage, which can be very nicely seen in children, but which is often indistinct in the adult. There are two different portions to be distinguished in the fibrous tissue by which the short process of the anvil is fastened to a corresponding depression in the bone. The portion (*d*) which is fastened to the processus brevis on its outer side differs from the rest (*e*) by its brilliancy, its yellowish color, homogeneous appearance, and indistinct striation, and consists of dense, almost homogeneous connective tissue, which is slightly altered by weak solutions of caustic potassa, and is friable, as it cannot be teased into shreds, but shows only gaps. The remainder of the ligament consists of common fibrous connective tissue, in some horizontal sections of which can be seen a peculiar fascicle (*f*) passing from the top of the processus brevis inward, and consisting of fine straight parallel fibres. The above-mentioned difference is noticeable even in the newly born, where the lateral portion of the ligament, as well as the last-mentioned fascicle, consist of fully-developed connective tissue with fine parallel striation, while the re-

mainder has still the appearance of embryonic connective tissue.

I may mention, in conclusion, that I have never seen the short process of the anvil in immediate contact with the bone in any place, although I have made many successive sections through the incudo-tympanic symphysis, according to the manner described above. I cannot, in the face of my microscopical preparations, agree with Helmholtz when he says (p. 38) "that the hammer, together with the anvil, has to be considered as a one-armed lever whose hypomochlion lies where the apex of the short process of the anvil stems against the wall of the tympanum."

The *Incudo-Stapedial Symphysis*, as well as the peculiar structure of the apex of the long process of the anvil, has been more fully described and illustrated in my former paper, to which I may here refer. For the sake of completeness, and in order to facilitate the comparison with the malleo-incudal symphysis, the drawing, Fig. 5, has been copied, and shows a great similarity between the two symphyses, and also several peculiarities which find their explanation in the different function, and especially in the cog apparatus of the malleo-incudal symphysis. The fixing (capsular) ligament is strongly developed also in the incudo-stapedial symphysis, and consists of similar fine, stiff fibres; here, too, are fibres arising from it which run between the cartilaginous ends of the anvil and stapes and complete a direct connection between the two ossicles by being united to their entire articular surfaces. This bundle of fibres is, however, much more delicate than the ligamentous disk of the

malleo-incudal symphysis, and the thickened edge is also wanting, because the two ossicles are in constant connection, not separating, as in the former, where a more strongly developed bundle of fibres has to fill up the gap. As the end of the anvil (resp.: processus lenticularis) is much smaller than the corresponding part of the stapes, and is at the same time markedly convex, it requires the interposition of a fibro-cartilaginous disk (*a*) thicker at the periphery than at the centre.

Rüdinger terms this likewise a bilocular articulation with a central meniscus; we, therefore, here also differ only in regard to the connection of the intermediate fibre-bundle with the cartilage. After looking over some old preparations made from three adults, I have again satisfied myself that there is no break between the interposed tissue and the cartilaginous surfaces; and considering the delicacy of the parts in question and the difficulty of preserving the connections intact, I believe this to be more conclusive than the opposing evidence. My view seems further strengthened by the striking analogy of the incudo-stapedial with the malleo-incudal connection, which, in my opinion, is beyond doubt a symphysis. Furthermore, I cannot see of what use a meniscus would be in excursions so extremely small, which necessitate the utmost precision, especially when we consider the peculiar form of the articulating surfaces.

I have stated that the tendon of the stapedius may exert an influence upon the tension of the symphysis because its upper fibres are inserted into the connecting ligament, but I cannot agree with Rüdinger's assertion,*

* Monatsschrift f. Ohrenheilkunde, 1872, p. 32.

that a portion of the stapedius muscle is inserted into the processus lenticularis of the anvil.

In the newly born this symphysis presents the same appearance as the malleo-incudal symphysis; here also is a continuous layer of cartilage from the anvil to the stirrup, and the fibrous nature of the interposed tissue can scarcely be traced.

As to the

Symphysis between the base of the Stapes and the Oval Window,

I have nothing new to add. Here also the connection between the cartilaginous rings of the base of the stapes and the oval-window is made up of fine, straight connective-tissue fibres, as shown by the investigations of Eysell, Buck, Rüdinger, and myself. Rüdinger has also found lacunæ in the interposed tissue, and, therefore, calls this connection a semi-articulation. My investigations would lead me to consider these lacunæ as artificial, and I may be allowed to quote the following passage from my former paper (p. 25): "In good preparations the interposed connective tissue does not show a central cavity nor any separation of continuity, but the central part (nucleus) seems to differ in certain respects from the peripheral parts; exhibiting the fine striation less, appearing more homogeneous, with some interspersed cartilage-cells (which, however, are also found here and there in the peripheral parts), and being more deeply stained with carmine. In some preparations this middle part is broken, which seems to indicate that it is more delicate than the other parts." Neither Eysell nor Buck mention any such cavities as being physiological.

The foregoing description shows that all the connections of the ossicles which are situated in the course of the sound-waves, have a similar arrangement in which the cartilage plays an important part. The same holds good in the

Connection between the Hammer and the Membrana Tympani, in reference to which I will add a few cursory remarks referring to Fig. 6, which is copied from my previous paper. The hammer, as far as in connection with the membrana-tympani, and even a little farther, is covered with a thin layer of cartilage, with which the fibres of the membrana-tympani are uninterruptedly continuous, as in the above-described symphyses.

The cartilage, which is hyaline and particularly well developed on the processus brevis, not only in the small bridge which unites the handle with the drum-head, but surrounds the greater part of the outer surface of the hammer, penetrates the osseous substance, particularly at the lower third, which has to sustain the greatest shock of vibrations. It is to be supposed that by this arrangement the thin handle is rendered more elastic and less fragile. There is no separation between cartilage and bone, as erroneously asserted by Gruber, the contiguous surfaces being ragged and by no means smooth. I think it of importance to state this, because this view of Gruber has been adopted by Helmholtz in his "Mechanism of the Ossicles of the Ear." * On the con-

* Helmholtz says, l. c., p. 17: In the vicinity of the lower end of the handle the connection of the bone with the thickened tissue of the membrana-tympani is very firm, but in the vicinity of the short process there is a more yielding substance or even a kind of incomplete articular fissure between the bone and the membrana,

trary, the handle of the malleus is united to the membrane throughout its entire length, including the short process, the connecting bridge corresponding on the whole (excepting individual variations) to the middle of the outer surface of the handle, its thickness increasing downwards in proportion to that of the handle. This latter condition alone renders movements of the hammer on the membrana-tympani possible. Near the short process the circumference of the bone is large, but the connecting bridge is narrow, so that a transverse section shows an elongated triangle, with obtuse angles, the base of which looks inward, while its apex rests upon the membrane. On the other hand, the spatula-formed end of the hammer is wholly enveloped by the membrane, its greater diameter lying in the plane of the membrane.

By means of this attachment the upper part of the handle, together with the short process, can be easily rotated on an axis which passes through the middle of the connecting bridge, so far as the spatula-formed end of the hammer and its other attachments admit of such a rotation.

I will not decide the question whether or not the short process slides upon the membrane as a whole. Although the attachment I have just described seems to

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which substance is rendered firmer on both edges by the union of the periosteum of the hammer with the edges of the cartilaginous layer and the fibrous tissue of the membrane.

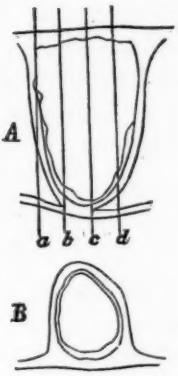
And on p. 32: At the same time it will be seen that the short process of the hammer must slide on the membrane in these movements, which sliding is possible on account of the peculiar connection between these two parts described by J. Gruber.

render it improbable, yet I would not deny the possibility of very small, especially lateral, movements, which alone come into question, because a little yielding of the connecting bridge seems not impossible.

In my previous paper I have described a slit-shaped cavity appearing in longitudinal sections of the hammer, in reference to which I wish to make a few remarks. It is, as illustrated in Fig. 6, bounded to the outer and inner side by fibres of the membrana-tympani, and its inner surface is covered with pavement epithelium.

If longitudinal sections are made through the hammer, vertically to the surface of the membrane, the slit-shaped cavity is seen reaching farther up, but not down in the sections nearer the edges than is shown in Fig. 6. In the sections near the middle the cavity becomes smaller and disappears altogether in two or three sections made directly through the middle in the longitudinal axis where the bridge which connects the handle with the membrane is cut through, but if we continue the sections the cavity reappears.

A glance at the accompanying diagram (*A* representing a section through the upper and *B* through the lower third of the handle) illustrates what has been said. In A the longitudinal cuts only, from *b* to *c*, will not show any separation, because they would go through the connecting bridge, whilst a cavity will appear as soon as the section passes through the acute angle formed by the membrana-tympani with the lateral surfaces of the hammer.



In the lower third, where the connection between the hammer and the membrane is broader, no such cavity can be seen in a longitudinal section. Now it is evident why the opening is lined with pavement epithelium—the epithelium of the inner surface of the membrana and of the ossicles—and why it is surrounded by fibres from the membrane which, as is well known, encircles the hammer.

This is in harmony with my former investigations, except I supposed the posterior cavity was a lacuna between the fibres surrounding the hammer and those that pass from the membrane to the hammer,* but I have satisfied myself that this lacuna is not constant, and I have also made a drawing of a bridge consisting of a granular substance and situated in the anterior deep furrow (looking towards the tube) between the membrana and the outer surface of the hammer. This bridge I am now inclined to consider as accidental.

* L. c., pp. 18 and 20, Figs. 9, 10, and 13, *e*.

I have nothing new to add on the manner in which the fibres of the membrana pass over to the hammer, and on their course, as I have not given the subject sufficient attention, but I am sure there are many interesting facts still to be found.

In my recent researches my opinion has been confirmed, that the connection between the hammer and the membrana does not exactly coincide with the middle line of the outer surface of the hammer, but with a line lying more towards its posterior edge, while at the anterior edge a more or less deep fissure is found where the hammer only lies against the membrane: * I, of course, speak only in reference to the middle and upper parts of the handle. This is certainly of great importance in the mechanism of the parts, because the hammer is more easily rotated upon its longitudinal axis in one direction than another. I will not decide the question whether this has any relation to the eccentric insertion of the tensor-tympani into the anterior edge of the inner surface of the malleus.

I have again been struck with the looseness with which the middle and upper thirds of the handle are connected with the membrane. I have again obtained transverse sections like those drawn in Figs. 14 and 15 of my previous paper.

APPENDIX CONCERNING PRUSSAK'S SPACE AND THE POUCHES OF THE MEMBRANA TYMPANI.

In the *Archiv für Ohrenheilkunde*, vol. 3, p. 265, Prussak has described a space between the membrana-

* Compare Figs. 10 and 11, l. c.

flaccida and the neck of the hammer which he calls the *upper pouch of the membrana-tympani.* Its borders are, according to his description, as follows: To the *outer* side, the membrana flaccida (see *K*, Fig. 6, Tab. IV.); to the *inner* and *lower* side, the neck of the hammer and the upper surface of the short process; to the *upper* side, a ligamentous membrane which passes from the margo-tympanicus to the spina mallei (evidently the ligamentum mallei externum); to the *anterior* side it is bordered by the anterior duplicature of the membrana-tympani, that is, the upper blind end of the anterior pouch; to the *posterior* side it communicates, above the posterior pouch, with the drum-cavity by a moderately large opening.

I have already stated my conviction that this upper pouch of Prussak is identical with the space *K*, Fig. 6, which I have found constant in all longitudinal sections, but formerly I could not trace the lateral connection between this space with the tympanum. I think every one who compares Fig. 6 with Prussak's description will be convinced of this identity. Prussak's drawings, however, are somewhat deficient, and for this reason his statements have been misunderstood by some, for instance by Helmholtz.* For the majority of cases I can confirm the statement of Prussak that this upper pouch has only one orifice, lying behind and above the posterior pouch, between the processus brevis and ligamentum posticum (*b* in Fig. 8), and admitting of the introduction of a moderate-sized probe. Nevertheless

* L. c., p. 20.

this opening, in one case, was connected with the anterior pouch, so I think there may be individual variations. The anterior pouch usually ends in a cupola-like cul-de-sac and on a level with the short process and the spina tympanica major; and the septum which separates it from Prussak's space can be seen by transmitted light from outside. It is the line which passes from *a*, Fig. 7, to the hammer, and which separates the membrana-tympani proper from the membrana-flaccida.

On account of its narrow entrance Prussak's space is easily filled with mucus, occasionally causing its rupture. To this condition certain appearances in the living may be referred, showing, immediately above the processus brevis, a cupola-like, dull, glistening, somewhat prominent place resembling a small sago grain. But I cannot share Prussak's view, that the vibrations of the upper end of the lever-shaped hammer are interfered with by such an accumulation of mucus, because the movements in question are too small and the walls of the cavity are rigid only in some places.

To illustrate these conditions I have added two drawings (Figs. 7 and 8), representing the inner and outer surfaces of the membrana in connection with the hammer. In order to show the parts inside, the anvil was removed.

In Fig. 7, at *a*, we see the spina-tympanica major (Helmholtz),* and at *a'* the spina-tympanica minor, and between them the Rivinian recess is situated. If light is thrown obliquely on the membrane, the free margin

* Henle (Handbuch der Anatomie, vol. 2, p. 738) calls it the spina tympanica posterior, not referring to the Rivinian recess.

of the posterior pouch is visible at *c*, with the chorda tympani entering at *d* into the projecting bony ledge; besides, a cord is to be seen passing from the spinæ tympanicæ major and minor to the hammer, separating the membrana-tympani proper from the membrana-flaccida, which is situated in the Rivinian recess, contains no fibres from the membrana-tympani but only common connective tissue, and has been called by Helmholtz the upper supporting ligament of the drumhead. The posterior part of this cord arising from *a'* is the longer, and represents at the same time the line of insertion of the posterior pouch into the drum membrane; *b* is the region of Prussak's space, or the upper pouch. I do not think that it extends as far as the whole membrana-flaccida, as stated by Prussak; on the contrary, it occupies only a portion of it, as can be seen by its entrance, represented in Fig. 8.

The Rivinian recess, as is well known, serves two purposes; first, it allows space for the upper part of the hammer and its excursions, and secondly, it furnishes places of attachment for the mallear ligaments. It surrounds the neck of the hammer, as can be seen in macerated temporal bones, like a narrow semicircular cornice to which are attached the ligamenta mallei anticum, externum, and posticum, the principal supports of the hammer. In many preparations, the spina tympanica major especially encircles the neck of the hammer like a sharp hook with its point looking backwards.

In Fig. 8 the relations of the posterior pouch to the drumhead and the membrana-flaccida are shown, as well as the entrance of the upper pouch. I have taken

particular pains to illustrate the articulating surface (*sit venia verbo*) of the hammer. It will be seen that the line of insertion of the posterior pouch into the drum-head crosses the chorda tympani and reaches the hammer somewhat below the place where the chorda leaves it.

The chorda, always following the free margin of the pouch, causes the arrangement represented in the drawing, viz.: the pouch appears twisted upon its axis (like a towel when wrung), its anterior quarter opening in an upward direction, but not downward like the other three quarters. This arrangement was found at least in the specimen taken for illustration, as well as in several others, but I willingly confess that, as to these minor details, many variations may occur.

At *b* the posterior bundles of the ligamentum externum are seen, which Helmholtz describes as ligamentum posticum, and a little below, a lateral, *i.e.*, posterior view of the short process is obtained, between which and the ligamentum externum, is the entrance to the upper pouch of Prussak. At *a* is the place where I have always found the chorda attached to the long process of the anvil. (This attachment is constant, also, according to Henle.)

While the posterior pouch shows true fibres of the membrana-tympani, which run principally in the direction of its free margin, I could not find them in sections made through the anterior pouch, which deserves its name less than the posterior, and has been over-estimated in its significance. I consider it a mere duplicature of the mucous membrane which lines the structures

entering the Glaserian fissure, and is reflected from the neck of the hammer to the spina tympanica major and to the tendon of the tensor-tympani.

The significance of the posterior pouch also is not yet definitely ascertained, and it remains to be determined whether its main function is to support the hammer, or the chorda tympani.

EXPLANATION OF THE FIGURES IN PLATES III. AND IV.

All of the Figures, with the exception of Figs. 7 and 8, have been drawn by the aid of the camera lucida. Figs. 5 and 6 are taken from my paper, "Beiträge zur Anatomie und Histologie des mittleren Ohrs."

TAB. III.

Fig. 1. Horizontal section through the upper half of the malleo-incudal symphysis of the adult. *H*, head of hammer. *A*, body, and *A'*, short process of anvil. *P*, outer wall of the tympanum. *a*, hyaline cartilage; *b*, thickened edge; *c*, capsular ligament on inner side; *c'*, same on outer side; *d*, faintly striated but more homogeneous connective tissue, of a peculiar lustre, from the outer portion of the incudo-tympanal connection; *e*, ordinary connective tissue; *f*, a fascicle with delicate and parallel fibrillæ.

Fig. 2. A deeper section of the under half of the symphysis, being in the same direction, and viewed with the same power, and lettered the same as in Fig. 1. From *c'*, the outer capsular ligament, a fascicle of connective tissue passes to the opposite wall of the tympanum.

Fig. 3. 70 *diam.* Horizontal section of the upper portion of the malleo-incudal symphysis of the adult, as in Figs. 1 and 2. The connection was intentionally loosened, and the greater part of the line of separation passes through the ligamentous disk. *H*, hammer. *A*, anvil. *a*, bone; *b*, hyaline cartilage; *c*, ligamentous disk (fibro-cartilaginous); *d*, thickened edge; *e*, outer, *c'*, inner capsular ligament.

Fig. 4. 100 *diam.* From the adult, section as above. Portion of ligamentous disk united to the hyaline cartilage. *a*, bone (malleus);

b, hyaline cartilage; *c*, ligamentous disk. Incudal portion of disk not drawn.

Fig. 5. 90 *diam.* Section, from the adult, through the end of long process of anvil and incudo-stapedial symphysis, horizontal to the long process of the anvil and perpendicular to the membrana-tympani. *A*, long process of anvil. *A'*, Os-Sylvii. *B*, head of stapes. *a*, fibro-cartilaginous disk; *b*, hyaline cartilage, the cartilage-cells being wanting in the immediate vicinity of the ligamentous disk, therefore a small stripe of hyaline matrix, *c*, appears; *d*, stripe of connective tissue passing through the middle of the symphysis (ligamentous disk); *e*, capsular ligaments; *f*, tense connective tissue.

Tab. IV.

Fig. 6. 20 *diam.* Longitudinal section through the hammer, perpendicular to the membrana-tympani, of the adult. *A*, rim of bone at the upper (Rivinian) recess of the membrana-tympani. *B*, head of hammer. *C*, neck of hammer. *D*, handle of hammer. *E*, processus brevis mallei. *F*, membrana-flaccida. *G*, ligamentum externum mallei. *H*, chorda-tympani. *I*, tendon of the tensor tympani. *K*, Prussak's upper pouch of the membrana-tympani. *a*, cartilage; *b*, fibres of the membrana-tymp.; *c*, dermoid layer of the membrana-tymp.; *d*, cavity; *e*, haversian canals; *f*, small medullary space.

Fig. 7. Outer view of the membrana-tympani when held obliquely toward the light. *a*, spina tympanica major (Helmholtz); *a'*, spina tympanica minor; *b*, Prussak's upper tympanic pouch; *c*, free edge of the posterior pouch (chorda-tympani); *d*, bony ridge at the entrance of the chorda-tympani.

Fig. 8. Inner view of the membrana-tympani, with the anvil removed. *a*, portion of the free border of the posterior pocket of the membrana-tymp., where the chorda is constantly found fastened to the long process of the anvil; *b*, ligamentum mallei posticum; the processus brevis mallei is visible a little below its anterior border; and between the ligament and the process is found the entrance to the upper pouch. The membrana-flaccida extends to the posterior pouch below the ligamentum posticum; *c*, ligamentum externum et anterius mallei; *d*, cut end of the tendon of the tensor tympani; *e*, cog of the hammer; *f*, facial nerve.

CONTRIBUTIONS TO THE PATHOLOGY AND PATHOLOGICAL ANATOMY OF THE ORGAN OF HEARING.

By Dr. S. MOOS.

(Translated by Dr. C. C. Terry, New York.)

In the following paragraphs I shall describe a series of post-mortem examinations of diseased ears. If the careful reader find some data which are of value, not alone to the specialist, but to the general practitioner, I beg to state that the credit is primarily due to those of my colleagues who so liberally furnished me the histories and specimens.

Case I.

Casual discovery of aural catarrh in a case of fatal accident.

K., a robust peasant, 22 years of age, was run over by a railway train, July 3, 1872, and his body nearly cut in two just below the ribs. Thirty-six hours later the autopsy was made by Prof. Knauff. Besides other lesions not pertaining to the auditory apparatus, there were found numerous ecchymoses in the meninges of the anterior cerebral lobes. . No other abnormity on and within the skull.

In the naso-pharyngeal cavity evidences of a considerable catarrh. Only the right petrous bone could be examined soon after death. The upper and lateral portions of the external auditory canal, in the vicinity of the drum-head, and the vessels of the handle were injected. Drum-head

itself infiltrated with serum, showing no reflex, markedly concave. The attempt to blow air through the tuba by means of a catheter was met by a considerable resistance, which only gradually gave way with a bubbling sound, followed by the escape of viscid mucus from the pharyngeal end of the tube. The condition of the drum-head remained unchanged. A bulbous sound of 1 mm. in diameter could not be passed through the tube into the tympanum. In the tube itself much glairy mucus, which exhibited under the microscope mucous corpuscles, granulated cells, and cylindrical epithelium.

Mucous lining of the cartilaginous part of the tube very much reddened, but gradually becoming paler in the bony part of the tube and yellow on the labyrinthine wall of the tympanum. It is much thickened and pervaded by isolated varicose vessels, whereas the inner surface of the drum-head is brightly injected. In the antrum mastoideum the injection was more pronounced than on the wall of the labyrinth, increasing toward the mastoid cells, the mucous lining of which was bright-red. The lower half of the tympanum was occupied by serum.

Malleo-incudal articulation free. Mobility of stapes reduced. After removal of their hypertrophied mucous covering, the incus and malleus appeared dark-red. The fibrous and osseous walls of the porus acusticus internus and sheath and trunks of the facial and acoustic nerves were suffused with blood, and this condition extended as far as the first curve of the facial nerve, and the entrance of the acoustic nerve into the axis of the cochlea.

The microscopical examination of the internal ear discovered nothing more of interest.

In a practical point of view the diminished mobility of the stapes is remarkable. A successful evacuation of the exudation by puncture during life would not have perfectly restored its function. The serous effusion into the tympanum must be considered the consequence of the hyperæmia and the occlusion of the Eustachian tube.

Case II.

Nephritis parenchymatosa chronica. Hydrops anasarca. Chronic aural catarrh on both sides. Hyperæmia of the right, hypertrophy of the left tympanic mucous membrane.

Franziska Baier, a patient in the medical clinique, became affected with ear and eye disease, after having been treated for morbus Brightii several months in Prof. Friedreich's wards. On the 26th of May she complained of pain and noises in both ears; and on the 3d of June of headache, which wore off the next day. On the 8th of June a drastic cathartic was administered, after which the pains and noises in the ear gradually diminished, until by the 14th of June she considered the ears entirely recovered. June 18, uræmia.

I examined the ears on the 21st of August, 1871, one month before her death. She denied to have had ear-disease previous to the end of May, considered her hearing to be normal, and complained of no subjective symptoms. On the day previous there had been singing in the left ear. Both external auditory canals were clear, only a slight hyperæmia existing superiorly at their inner ends. The right drum-head appeared normal, with the exception of a slight opacity of the mucous surface; but the left showed a marked marginal opacity, was quite concave, almost funnel-shaped; below the handle a small lentil-shaped dark spot (atrophy?). Hearing distance for whispering, 7 feet on the right side, 3 feet on the left; for a small watch, 12″ and 3″. Conduction through the bones good on the right side, weak on the left. Tuning-fork perceived only on left side.

On the part of the eye Prof. Becker diagnosticated venous hyperæmia of the retina, April 6; at that time the papilla was unaffected. On the 1st of July the contour of the papilla was barely distinguishable, the vessels on the left side were clearly perceptible, especially at the periphery. A little later the process was still more advanced, the papilla was no longer to be made out, and the vessels were veiled. Diffuse opacity of the fundus; hæmorrhages at the extreme periphery. July 25, intense retinitis in both eyes, together with striped opacity in the region of the papilla, isolated white spots and numerous ecchymo-

ses are seen in various stages of regression. There was a fine display of regularly disposed white spots in the region of the macula lutea, especially in the right eye. The secondary neuritis was not very intense, especially not in the right eye.

Death occurred September 19. Autopsy the same day.

Anatomical diagnosis: Granular atrophy of both kidneys; Cholelithiasis; Hydrops ascites et Anasarca; Hydrothorax dexter; Hypertrophia ventriculi cordis sinistri.

Examination of the petrous bones.

Right petrous bone. Inner end of external auditory canal reddened above. Forcing air into the middle ear caused considerable motion of the posterior half of the drum-head; the anterior half was less movable. Drum-head opaque and infiltrated with serum; anterior half abnormally concave; short process and handle perceptible. Mucous lining of the Eustachian tube pale; mucous lining of the entire middle ear and antrum mastoideum very much reddened, more so than the lining of the mastoid cells. Microscopical examination of the mucous membrane showed the capillaries crowded with blood-corpuscles. Numerous granular globules, and many cells furnished with processes, were seen upon the mucous membrane. The ossicles were readily movable, but injected, the malleus least. On the floor of the tympanic cavity there was a quantity of serum.

Left petrous bone. External auditory canal same condition as right. Inflation of the tympanum caused no movement of the drum-head, which was lustreless and tendinous in appearance at the periphery. At a little distance below the end of the handle there was a sunken spot as large as a lentil (atrophy or scar?). Mucous lining of the entire middle ear considerably thickened. The microscope showed a proliferation of the connective tissue, which again contained many small cells; the stellate cells were less numerous than on the right side, and cells in a state of fatty degeneration were entirely absent. The vessels were in the same condition as on the right side. The ossicles, covered by hypertrophied mucous membrane, were

quite movable. E. tube free. Proliferation of connective tissue in Rosenmüller's fossa.

Examination of the ear during life, and again after death, showed that the aural affection was not directly related to the kidney disease; the condition of the eyes, however, depended upon that of the kidneys. In all probability there existed, previous to the occurrence of the renal disease, an old catarrhal disease of the throat and the middle ear, with serous effusion into both tympanic cavities. The process was further advanced in the left ear than in the right; and as the patient had no recollection of any discharge from that ear, the above-described appearance of the left drumhead is more correctly ascribed to atrophy than to cicatrization. The absence of mobility in the left drumhead is easily explained by the hypertrophy of the mucous membrane.

Case III.

Meningitis cerebro-spinalis. Extension of the inflammation along the dura mater into both tympanic cavities. Integrity of the nervous apparatus.

Michael Busch, æt. 22 years, entered the hospital June 29. Was healthy until fourteen days previous to his admission, when he began to feel ill. He was peevish and fretful, and complained of feeling very tired. Ten days previously he began to complain of pains in the head, loins, and limbs; walking caused pains in the feet. The headache was especially severe in the occipital region, extending thence to the neck and down the back; at the same time there was pain in the eyes, which were red and very lachrymose; inappetency; constipa-

tion. The pain of the back radiated to the abdomen. The dejections were not involuntary.

After having lain nine days in bed he had a severe chill, became delirious and violent, struggled with the attendants, bit them, and tried to get out of bed. This state continued until the present. He was sleepless. Vomiting occurred frequently in the first days of the disease. At the same time frequent singultus and grinding the teeth. There were no convulsions of the limbs or the face.

Status præsens. Paralysis of both abducens muscles. The mobility of the tongue was not affected, the swallowing movements were impeded. The muscles of the neck were tense, and felt hard; the attempt to move the head, and even the touching of the cervical muscles, was attended with pain. The loins were especially the seat of pain. Herpes labialis. Temp. 38.2.

Treatment.—Ice-bag to the head. Six leeches to each mastoid region. Cold affusions upon the head, while the body was immersed in warm water. Three powders of calomel and jalap, āā 5 grains. Lungs and heart normal. Spleen enlarged; hyperæsthesia of legs and arms, especially of the right side. Quinine in solution, gr. xv. ad ℥ v. At one o'clock a bath of 28, with cold affusions. The headache diminished somewhat.

After three o'clock great restlessness, high delirium, loud complaints of lumbar pain, frequent grinding the teeth, much thirst. Urine 1025, containing no albumen. Pupils widely dilated. Temperature, 39.4. Pulse, 90.

Became more delirious towards evening, but a warm bath with cold affusions quieted him for the greater part of the night. Frequent spasms of the extremities were noticed, but no grinding of the teeth. During the night two thin stools were passed, but not in bed.

June 30. Temp. 38.2. Pulse 90. Patient answered at random; he lay quietly; frequent jerking of the arms or legs was noticed; now and then complained of pain in the back. The surface, so very sensitive the day before, had lost its hyperæsthesia. The pupils were still widely dilated.

In the course of the day the sensorium appeared to be less oppressed; the patient answered more pertinently. The spasms of the limbs

were less frequent, and the physical excitement had abated. Stool, not in the bed. Temp. 37.8. Pulse 90.

At	7 o'clock	37.8
"	9 "	38.0
"	11 "	37.6
"	1 "	37.8
"	3 "	37.8
"	5 "	38.0
"	7 "	39.2

In the first part of the night great restlessness, struggling to get out of bed; violent delirium; spasms in the right arm. Brygmus. *For the first time*, spasms of the muscles of the face. Next morning quiet; answered that the pain in head and back had moderated. Pupils reacted normally. One stool.

July 1. T. 39.2; P. 80.	At	9 A.M.,	T. 39.4	
" " 38.4; " 84.	"	11 "	" 38.6	
	"	1 P.M.,	" 39.4	
Two stools, *stat.* idem,	"	3 "	" 39.2	
less paralysis of	"	5 "	" 38.4	Three warm baths in
abducens.	"	7 "	" 38.2	course of day.
	"	9 "	" 37.4	
	"	11 "	" 37.4	
	"	1 A.M.,	" 38.4	
	"	3 "	" 39.0	
	"	5 "	" 39.6	
	"	7 "	" 39.6	

July 2. T. 39.6; P. 96. No stool. Fair night. Rested better. Passed water in bed. Cough since previous evening with muco-purulent sputa, tinged with blood. Swallowing less embarrassed.

July 2. T. 38.2; P. 96. Fæces in bed. Does not answer when spoken to (deafness). Eyes closed. Sensibility diminished. No jactitation. Swallowing unembarrassed. Expectoration ceased.

July 3. T. 38.8; P. 100. Urine and fæces in bed. In the night he talked and sang in delirium. No spasms.

Temperature during night: 9 P.M., 38.2
11 " 38.4
1 A.M., 38.4
3 " 38.2
5 " 38.2
7 " 38.0

Ptosis. No response.

1 P.M., 38.6
3 " 39.2

Cheeks dilated by expiration. The hyperæsthesia ceased. Evening: Urine in bed. Pulse very rapid. Stat. id. 39.6, 124. The patient died in a comatose condition at half-past two in the morning.

Autopsy by Prof. J. Arnold. Rigor mortis marked. Surface pale. Adipose tissue moderate in quantity. Muscles dark-red and well developed. Cranium thin but compact. Sutures normal. A number of pit-like depressions on the inner surface of cranium.

In the longitudinal sinus dark fluid blood and a fresh clot. The pia mater showed great repletion of the veins, besides a high degree of capillary hyperæmia. At the top of the convexity the pia was more opaque, especially along the course of the large vessels. Here and there the opacity had a granular appearance. In some meshes of the arachnoid, yellowish material. The convolutions of the cerebrum were remarkably smooth. The sinuses at the base of the brain stuffed with dark fluid blood, and the pia mater diffusely opaque. The meshes of the arachnoid over the chiasm and pons dotted with yellowish, purulent masses. In the fossæ Sylvii the pia was on both sides very vascular, and exhibited a high degree of serous imbibition. Arachnoid of medulla oblongata infiltrated with pus. Removal of the pia from the convexity accomplished only with laceration of cortical substance, which was deeply tinged, considerably hyperæmic, and softer than normal. Lateral ventricles dilated, filled with turbid serum, which, especially posteriorly, contained yellow flocculi. The ependyma was diffusely opaque, slightly granular, and the vessels below it were turgid.

The mass of the cerebrum was evidently hyperæmic, much infiltrated with serum, and softened; the cerebellum, pons, and medulla oblongata exhibited similar changes in a less degree.

On opening the spinal canal, the external surface of the dura mater spinalis was found to be hyperæmic throughout its whole extent. In the dura and pia, and the meshes of the arachnoid, purulent infiltration, which was most evident at the upper cervical and lower lumbar parts, but more so posteriorly than anteriorly. At the site of the cauda equina was a collection of pus, which formed a large sac. The substance of the marrow showed no particular change in the upper regions, but in the lumbar parts the gray substance was hyperæmic.

The details of the lesions on the part of the thoracic and abdominal organs are sufficiently indicated in the anatomical diagnosis: Meningitis cerebro-spinalis. Suppurative pleuritis on right side. Hepatization of the right lower pulmonary lobe. Enlargement of the spleen.

Examination of the petrous bones.

The dura mater covering both petrous bones showed the above-mentioned changes, and was not easily separable; its prolongations entering the cavities of the bones were quite hyperæmic.

The sheaths of both auditory nerves hyperæmic as far as the entrance of porous acusticus internus, but in the canals both nerves and sheaths normal. Microscopical examination of the hyperæmic parts of the sheaths showed congestion of the vessels and cellular infiltration. The osseous covering of the middle ear dark-red, especially posteriorly, more on right than left side.

In the right external auditory canal a hard, dark mass of ear-wax lying against the drum-head. At the inner end of the canal there was some redness of the upper wall and a less degree along the handle. The posterior fold of the drum-head well marked; the anterior half of the membrana tympani was quite concave and more transparent than the posterior. No light spot. Peripherically, anteriorly and below, was a considerable opacity of the mucous layer. The so-called membrana flaccida was very small, and showed in its middle portion a round pit-like depression, about 1 mm. in diameter.

Mucous lining of middle ear very vascular, hyperæmic and thickened. The lining membrane of the Eustachian tube normal.

At the bottom of the tympanic cavity some serous fluid. A sound of 1 mm. in diameter passed through the Eustachian tube. Inflation caused bulging of the anterior half of the drum-head, but the posterior remained motionless. Malleo-incudal joint and stapes less movable than normal. The macroscopical as well as the microscopical examination of the vestibule, the semicircular canals, the cochlea and their membranous parts, gave only negative results.

Left petrous bone. External auditory canal free, upper wall of its inner end, as also the neighboring parts of drum-head and the handle hyperæmic. Membrana flaccida larger than on the right side, and without a pit-like depression. Epidermic and cuticular layer of the posterior half thickened, the handle consequently less visible. Some serum at the bottom of the tympanic cavity.

Mucous membrane of middle ear both hyperæmic and thickened, but less so than on the right side. Tube in same condition as right. Inflation caused some movement of both halves of the drum-head. Mobility of the ossicles normal.

Sheaths of both tensor tympani muscles hyperæmic, but the fibrillæ appeared normal under the microscope. Labyrinth normal.

The foregoing case illustrates the rare occurrence of a meningitis extending to the middle ear without implicating the nervous apparatus. The way chosen was by the prolongations of the dura mater which pass to the middle ear. Had the disease lasted longer probably there would have been exudation and proliferation of connective tissue, changes which Klebs * first described

* Klebs on "Epidemic Meningitis," in Virchow's Archiv, vol. 34. In the case of a subordinate officer whose hearing was previously good, and who died in the fourth week with extreme exhaustion and total deafness, "the acustici exhibited nothing abnormal, and the terminal apparatus of the nerves showed no lesion to explain the deafness. But in the tympanic cavity were found relics of a very extensive inflammatory process in the form of numerous thick vascular bands of connective tissue which radiated from the ossicles on all sides to the walls of the cavity."

in the tympanic mucous membrane of fatal cases of cerebro-spinal meningitis.

Notwithstanding the rapid course of the meningitis, the integrity of the nervous apparatus is very remarkable, especially if we consider the early extension of the inflammatory process to the middle ear.

Case IV.

Chronic suppurative inflammation of the right tympanic cavity. Destruction of the drum-head. Caries, with formation of polypi. Inflammation of the membranous labyrinth. Meningitis. Abscess in the right temporal lobe.

K., of Heidelberg, 3½ years old, was brought to me by his mother, May 5, 1872. During a year and a half he had suffered from a sanguino-purulent discharge from the right ear. Latterly the blood had flowed in greater proportion. On examination, the left ear was found normal, but the right was filled by a polypus extending to the meatus auditorius externus. The boy had a lagophthalmus and was very much emaciated; I therefore advised good nourishment; and for fear of retention of pus, I suggested an operation as soon as practicable. I expressed my suspicion of caries, and gave an unfavorable prognosis.

May 29. The operation was made under chloroform. After the removal of numerous polypi, the drum-head was found to be entirely destroyed. By means of the probe I ascertained the existence of caries at the inner end of the canal.

June 8. I saw the patient for the last time. There was a fair amount of purulent discharge and no disquieting symptom.

Subsequently the family physician, Dr. Wolf, reported that in June the boy sustained a moderate attack of scarlatina, during the convalescence from which brain symptoms suddenly appeared. He died July 29.

Autopsy, July 30 (Prof. J. Arnold). Rigor mortis moderate; skin yellowish-white. Abdominal wall very tympanitic and discolored. But little adipose tissue under the skin. Muscles pale. Cranium of

medium thickness, pretty compact. Dura mater adherent, but no more so than usual in young subjects.

On the convexity the pia mater showed great repletion of the veins and slight diffuse opacity with serous infiltration, but at the chiasm and pons it was infiltrated with pus. In the right temporal lobe was a cavity as big as a small apple, filled with pus. Here the pia and dura were matted together and infiltrated with pus. Right lateral ventricle considerably dilated and filled with thin pus. The ependyma diffusely opaque and also infiltrated with pus. The cavity in the temporal lobe was lined by a thick wall of connective tissue covered and infiltrated with pus. The left lateral ventricle larger than normal and containing thin pus. Ependyma thickened. The mass of the brain was moderately hyperæmic, very moist, and in some places perfectly liquefied. The inner surface of the anterior portion of the dura mater was rather hyperæmic besides being infiltrated with pus, and at several places thickly set with cheesy deposits varying in size from a pin's head to a filbert. The lymphatic glands at the angle of the inferior maxillary bone were hyperplastic and partially cheesy; the subcutaneous cellular tissue behind the right ear contained also cheesy material. The muscular tissue of the heart somewhat pale. The bronchial tubes were filled with a large quantity of muco-purulent substance; the mucous membrane was correspondingly altered. The tissue of the upper lobe of the left lung contained air and was elastic; there were only a few atalectatic points. The lower lobe showed extensive atalectasis, spotted hyperæmia, and serous infiltration. By pressure, pus was caused to flow from the transversely cut bronchi.

Firm adhesions at the postero-superior region of the right lung. The tissue of the upper and middle lobes was altered in the same manner as the left lung. The lower lobe contained but little air, was dark red, and thickly set with foci of peribronchial inflammation. There was one spot of the size of a hazel-nut, which was particularly dense and callous.

Spleen considerably enlarged; capsule clear and translucent; tissue compact; Malpighian bodies larger than normal.

Kidneys normal in size, somewhat hyperæmic, and containing a large number of grayish-white dense nodules of the size of a millet-seed.

Liver pretty large; capsule transparent, and showing under it a large number of hard nodules of millet-seed size. The cut surface was intensely hyperæmic, its acinous structure indistinct; the tissue was pretty firm, and contained some white nodules. In the left lobe were two cysts, as big as peas, filled with bright-yellow bile. The portal glands were somewhat enlarged, pretty hard, and grayish. The mesenteric glands were enlarged and studded with white nodules.

In the lower part of the ileum the mucous membrane was quite hyperæmic, swollen, and opaque, and also studded with numerous caseous nodules varying in size from a pin's head to a millet-seed. Same appearances in the large intestine. In the vermiform process several of the nodules were ulcerated.

Anatomical diagnosis: Meningitis. Abscess of right temporal lobe. Broncho-pneumonia. Catarrh of small and large intestine. Miliary tuberculosis in liver and kidneys.

Examination of Right Petrous Bone. At the place where the meninges of the right temporal lobe were matted together (vide supra) on the inner anterior surface of the petrous bone, the dura was studded with white cheesy masses, varying in size from a pin's head to a hazelnut, and concerning whose essential character—whether granulation tissue or tubercle—the microscope furnished no insight. They appeared to consist for the most part of granular cells, with now and then a free nucleus. After the diseased portion of dura mater had been raised, it was proved that at the region of the cheesy nodules it was in a condition of intense hyperæmia, and which extended along its prolongations into the fissura petro-squamosa and into the tympanic cavity. *Along this fissure were scattered seven carious spots* of various size; the largest, almost of the size of a pea and nearly circular in outline, lay anteriorly opposite the eminentia arculata, and about three mm. distant from it. In the sinus and sulcus lateralis no lesion.

In the external auditory canal, and filling it entirely, was a polypus having its pedicle on the wall of the labyrinth. The bony septum between the auditory canal and the mastoid cells, and also the septa

of the cells, were carious. A probe could easily be passed from the auditory canal into the cells.

Membrana tympani destroyed. The annulus osseus existed only anteriorly. At the inner end of the auditory canal the bony roof was denuded. In the region formed by the floor of the auditory canal and the adjacent floor of the tympanic cavity, lay a sequestrum, and further inward, in front of the tympanic portion of the polypus, was lodged the displaced but otherwise uninjured incus, in such a position that the polypus, springing from the anterior portion of the labyrinthine wall, grew outwards between the two branches of the incus. Mucous lining of the middle ear hyperæmic and hypertrophied. Stapes anchylosed.

The connective tissue between the bony and the membranous semicircular canals, the canals themselves, the ampullæ, and the membranous sacs, all exhibited a considerable infiltration, mostly of small cells; so also the lamina spiralis membranacea of the cochlea, but in a less degree than the structures of the vestibule. In order to save the specimen the examination was not continued to the canalis facialis.

It is most likely that the entire disease was of a tubercular nature. Excepting the inflammation of the membranous labyrinth, the examination of the petrous bone developed nothing extraordinary. Considering the presence of caries and a sequestrum, the growth of a polypus after the operation was nothing strange. The fatal result could only have been prevented in this case, if the operation had been performed much earlier.

Case V.

Caries of Pelvis. Suppurative catarrh of the left middle ear with perforation of the drum-head. Numerous otoliths in the labyrinth.

Karl Gimper, died August 8, 1872. Autopsy, August 9. (Surgical Clinic.)

Anatomical diagnosis: Caries of crest of right ilium and right sacro-iliac symphysis. Pulmonary œdema and hypostasis. Amyloid degeneration of liver, spleen, and kidneys. Anæmia of the brain.

Left petrous bone. Dura mater easily separable from the petrous bone; osseous roof of the middle ear bluish red, very thin, and translucent. External auditory canal nearly filled with thin pus; cutis denuded; drum-head drawn far inward; in its antero-superior quadrant an opening as large as a pin's head, the different layers much thickened and grayish red; the handle invisible. The entire mucous lining of the tympanum was dark red and very much relaxed; malleus and incus covered by hypertrophied mucous membrane; malleo-incudal joint and stapes movable. In the labyrinth the most minute examination found nothing abnormal excepting an immense number of otoliths. There were no microscopical evidences of an inflammation having extended from the middle to the internal ear.

Perhaps this development of otoliths depended upon the suppurative disease of the bones. As is well known, Virchow first called attention to the fact, corroborated by subsequent observers, that in morbid processes of the bones attended with loss of osseous substance, for instance in suppuration of bone, osteomalacia, cancer, the so-called chalky metastasis may occur in parenchymatous organs, such as the kidneys, lungs, etc. Perhaps in the present case the otoliths were in this manner related to the caries of the pelvic bones. A larger experience may contribute to the solution of this question.

Case VI.

Old pleuritis on left side. Chronic tuberculosis of the lungs. Suppurative inflammation of right tympanic cavity: perforation and bulging of the drum-head: development of granulation-tissue in the tympanum. Collection of pus in the upper wall of the external auditory canal. Caries of malleus, incus, and mastoid cells. Integrity of the labyrinth.

C. S., æt. 49, suffered from pleuritis of the left side in the fall of 1868, gradually recovering with collapse of the chest-wall on that side. In the spring of 1869 tuberculosis commenced in both lungs, and terminated fatally June 20, 1870.

March 25, 1870, he came to me for the first time on account of an affection of the right ear.

History of the case. For five weeks, night and day, fearful pains in right ear, behind the ear, and in the occiput; complete deafness, with loud continual buzzing and knocking. Fever, sleeplessness, loss of appetite, and constipation.

Examination. Hearing distance almost nil; loud voice heard only when shouted into the ear.

But the watch and tuning-fork are heard distinctly by conduction through the bones on the affected side. (This remained to the end of life.) A little pus in the external auditory canal. Cutis slightly reddened. Line of demarcation between inner end of auditory canal and drum-head indistinct; drum-head red and thick; malleus invisible. Posterior half, especially the upper quadrant, bulging considerably. Directly below, in the region of the so-called sinus meatus auditorii externi, a granulation. On inflating the tympanum there was no hissing heard, the granulation did not move, nor were the subjective symptoms mitigated. Still, I thought there was in the lower part of the membrane a perforation occluded by the granulation. At all events, I made a large incision in the superior-posterior quadrant of the drum-head, and much blood and pus issued from the wound. There was no consider-

able mitigation of his sufferings either shortly after the operation or in the course of the night. On the following day the wound was found closed, while the middle ear remained impermeable by inflation. No pus appeared in the external auditory canal. I then removed the granulation. There was found a considerable perforation, which had been concealed by the granulation. Pus followed more freely, but the pains continued as much as before. The inability to sleep was considerably relieved during the last two days of the month by means of chloral, but during the first three days of the following month this means became unreliable.

In spite of the purulent discharge through the perforation, there appeared on the fourth day of April a considerable bulging of the superior-posterior quadrant, which was again incised. Much pus came from the wound; the patient was relieved during four hours.

The night following this incision was more comfortable; the patient stated that the discharge became more profuse at periods of three hours. On the following day I found but little pus in the canal. The incision was again healed excepting for a short distance. The bulging reappeared, and the air-douche drove out but very little pus. Incision. In the evening chloral. The night was comfortable. Towards morning, April 6, the same severe pains returned. Objective appearances the same as before the incision of the previous day. Incision. Pains from nine to eleven P.M., then rest till morning, when the pains again increased.

April 7. Same condition as before the previous incision. Incision repeated. Same course as before. Incision was repeated April 9th. After this incision the pain continued two hours, and followed by a comfortable night with no pain. The incision remained open, but now appeared a *new condition. On the upper wall of the external canal, at its inner end, was a pretty large swelling, whose long diameter lay in the direction of the long diameter of the canal. The pressure of the speculum caused some pain, but the tumor yielded easily.*

Now air easily passed through the perforation and brought with it a considerable quantity of pus. The permeability of the Eustachian tube was so far restored, that the patient made Valsalva's experiment successfully. But hearing was not improved. April 10th, but little

pain; Valsalva again. Profuse discharge. The same bulging of the upper wall of the external canal; contact with the speculum not painful. The patient stated that the spontaneous pain proceeded principally from the point touched by the speculum. When the canal was carefully cleansed and pressure made from the tragus inward, pus was observed this side the perforated drum-head, but it was impossible to find an opening in the tumor.

It seemed probable that the tumor was caused by an accumulation of pus and communicated with the middle ear. As the subjective symptoms were quite moderate, I delayed incising the tumor, but advised the patient to frequently press the tragus inward. Although I saw him daily until the 20th of April, and the discharge of pus by pressure on the tragus continued, I never was able to find the opening.

April 20th. I made a deep incision into the abscess; there was a free discharge of pus with collapse of the tumor. Although I had the patient under observation for more than a year until his death, I could never discover any symptom of caries or carious fistula in the external auditory canal. The disease appeared rather as a chronic, painless, suppurative, incurable aural catarrh, such as we so frequently see in tuberculous patients.

After the incisions of the wall of the canal and the drum-head had healed, the latter remained drawn inward toward the wall of the labyrinth, and exhibited at its centre a kidney-shaped perforation. The remnant of the drum-head, as also that part of the tympanic lining visible through the perforations, was grayish red and thickened. Nothing could be seen of the malleus, and the discharge was profuse. Until his death, June 20th, 1871, he did not again complain of earache. A fortnight before his death, I noted for the last time conduction through the bones for the watch and tuning-fork, and his ability to hear the voice shouted into his ear. His mental faculties remained intact to the last, and there were no cerebral symptoms.

Autopsy, June 21 (Prof. J. Arnold). Brain bloodless, infiltrated with serum, otherwise normal. Sinuses free; no evidences of caries; the osseous roof of the tympanum and of the mastoid cells was considerably rarefied. The left lung was perfectly compressed and airless, and bound to the wall of the thorax by the thickened pleura. In the

upper lobes there were cavities, as also throughout the right lung, excepting the lower half of the lower lobe. We omit the other data, as unessential as regards the condition of the ear.

Examination of the right petrous bone. Much fluid pus in the external auditory canal. Membranous wall everywhere uniformly thickened and merging into the external surface of the drum-head, which exhibits in its centre a large kidney-shaped perforation, while the rest of the membrane is grayish red and thickened. The malleus invisible. Through the perforation could be seen a portion of the labyrinth wall, which was grayish red, and at some points covered with pus.

Mucous lining of the middle ear, from the bony portion of the Eustachian tube into the mastoid cells, much thickened; considerable quantity of pus in the cells; the central part of the bony cells formed a large sequestrum lying free in the midst of the pus; the antrum mastoideum was also filled with pus. Of the incus there was left only the short process bound to the posterior tympanic wall by connective tissue, and appearing to project by its upper carious end almost across the tympanum. Of the malleus there was found only the carious head lying loosely against the upper tympanic wall, where during life it had been fixed by the hypertrophied mucous membrane. The tendons of the muscles of the middle ear were absent. The anterior half of the foot of the stapes was less movable than normal. In the cochlea and the semicircular canals neither macroscopic nor microscopic changes.

For those who in their practice are blessed with similar cases, the present offers many points of interest, both clinical and practical. I shall try to give a résumé of the case.

The disease commenced as an acute suppurative inflammation of the entire mucous tract of the middle ear, with early hypertrophy of the connective tissue, which soon caused an obstinate impermeability of the tube and a plugging of the opening in the drum-head. The consequence of this condition was a hernial bulging

of the drum-head, which necessitated six consecutive incisions, notwithstanding the perforation. Still the discharge was insufficient, and the pus forced its way from the middle ear into the tissue lining the external canal.*

The sequestrum found in the cavity of the mastoid cells was probably formed at this early stage of the affection; for it is not to be supposed that retention of pus was the only cause of the dreadful pain which continued so many weeks. The subsequent absence of pain—remarkable enough, considering the discovery of a loose sequestrum in the cavity of the mastoid—would be indeed wonderful had the sequestrum been formed at a later period. There was neither redness, swelling, nor pain in the mastoid region. Reasoning from these data, we might assume an acute osteoporotic detachment of the mastoid cells. Considering the complication of lesions in the early period of the disease, and the persistent insufficiency of purulent discharge—the patient coming under observation for the first time after five weeks had passed—it is quite incomprehensible that the brain and its envelopes were not involved.

The necroscopic conditions made it evident that in our case there had been an indication for trephining the

* In my examination of the petrous bone I eagerly sought for traces of the abscess in the wall of the meatus, but all to no purpose. The cuticular layer was everywhere in normal connection with the bone, and the bone-cells of the upper part of the osseous meatus which communicate with the tympanum were not unusually large. There was only the choice between spontaneous abscess and purulent accumulations by gravitation. Having in view the appearances described, I determined upon the latter opinion, despite the absence of signs in the above-mentioned bone-cells.

mastoid process, and yet during life there was nothing to justify it.*

The functional disturbances observed during life, and the hearing of the conduction through the bones when tried by the watch and vibrating tuning-fork, correspond with the necroscopic data, and are sufficiently explained by the lesions of the apparatus of conduction.

Case VII.

Autopsy of a deaf-mute. Periostitis of the temporal bone. Exostosis in the right tympanic cavity. Anchylosis of all the ossicles on both sides. Bony occlusion of both fenestræ rotundæ. Bony coarctation of the opening between vestibule and cochlea. General diminution of cavities in bony labyrinth. Chalky concretions in both internal auditory canals, and in the membranous sacs of both vestibules. No changes of nervous apparatus.

For the privilege of examining this case I am indebted to my colleague, Dr. Oscar Wolf, of Frankfort.

The parts examined were taken from a deaf-mute of 64 years of age, an inmate of the Frankfort Asylum.

Twelve hours after death the examination revealed the following conditions :

"Pericardium attached to the thoracic wall by fresh fibrinous adhesions ; in its cavity about five tablespoonfuls of serous fluid.

"Heart almost doubled in size. Left ventricle very much hypertro-

* In my collection are the two petrous bones from a case of tuberculosis which I studied during life ; they are carious in different places, and contain a central sequestrum in each mastoid process. During life there was intense pain on both sides, but the symptoms of inflammation of the mastoid cells, *i.e.*, redness, swelling, pain under pressure, etc., on the surface, existed only on one side.

phied and dilated; right ventricle moderately dilated. Insufficiency of mitral and tricuspid valves with short, wrinkled, and nodular margins (apparently results of inflammatory thickening of the subendocardial connective tissue). Envelope of liver opaque and thickened; liver shrunk at the anterior margin; thickening and opacity of envelopes of the spleen and kidneys; the latter were remarkably small and anæmic.

"Hepatization of lower portions of lungs, upper portions œdematous, and partly emphysematous.

"Brain-substance very dense and somewhat hyperæmic; Pacchionian bodies moderately developed. The auditory nerves appeared to me to be rather slender. Lateral ventricles moderately dilated, and containing about two teaspoonfuls of serous fluid. No other abnormity."

The petrous bones removed for examination exhibited at their margins a certain degree of sclerosis at the expense of the lamina vitrea, but without any considerable increase in thickness.

Right petrous bone. External auditory canal of medium calibre, and presenting no abnormity. The drum-head was drawn inward to a funnel-shape; its anterior half was transparent, its posterior opaque, excepting a little spot behind the middle of the handle; the vessels of the handle were hyperæmic. On the lower part of the drum-head appeared a curvilinear opacity, extending from the posterior across to the anterior margin, and with the summit of its arch at the umbo.

From the bony portion of the Eustachian tube to the vicinity of the antrum mastoideum the mucous lining of the middle ear was everywhere considerably thickened, and exhibited—as on the left side also—a great number of the pedunculate structures described by Politzer and Kessel, and considered by them physiological. Cartilaginous portion of tube normal. A sound of one mm. in diameter passed easily as far as the bony part of the tube (also on the left side), and gentle force carried it through the bony part also without injury to the mucous lining. The tensor tympani was well developed on both sides; its microscopic texture was entirely normal. Malleo-incudal articulation rigid, as also the tympanic connections of the incus; the stapes quite immovable.

The mucous surface of the drum-head, especially its posterior half,

was opaque, and the umbo was hardly one mm. distant from the promontory. From the floor of the tympanum, and covered by its mucous lining, projected a smooth, white, convex exostosis, which was so nearly in contact with the inferior portion of the drum-head that, viewed through the drum-head, it presented the appearance of a chalky concretion in that membrane. The tendon of the tensor tympani was somewhat shortened. The promontory, less convex than normal, appeared to be somewhat stunted. The cavities of the vestibule and cochlea were very small, the fenestra-rotunda occluded by bone, and the communication between vestibule and cochlea so diminished that a bristle could hardly pass.

Left petrous bone. Same condition of auditory canal as on the other side. The drum-head was drawn inward to a funnel shape ; it was normally transparent ; the vessels of the handle hyperæmic. The tendon of the tensor was much shortened, and the handle, especially its lower part, drawn considerably inward. Same conditions of malleo-incudal joint, incudo-tympanic connections, stapes, and tympanic mucous lining as on the right side. Condition of the communication between vestibule and cochlea similar to that of the other side, and the fenestra-rotunda occluded by bone.

Microscopical examination of the nerve and membranous labyrinth on either side furnished the following data :—

On the inner surface of the periosteum, at the inner end of the porous acusticus internus, as also on the nerve-sheath, there were great numbers of those singular concretions of phosphate of lime described and figured by Arthur Boettcher in *Virchow's Archiv*, Bd. XII., S. 104, *et seqq.* The same kind of bodies were found in the membranous sacs in both vestibules. In regard to those found in the auditory canal, I can add nothing to Boettcher's description. Those lying upon the nerve-sheath were, with few exceptions, isolated ; a few were round, some were lemon-shaped, but the predominant form was clubbed. They all showed a concentric arrangement of structure, and on many of them could be demonstrated a concentrically arranged organic envelope. Those on the membranous sacs varied remarkably in size ; some were pale and glistening, a few light yellow, nearly all appearing ho-

mogeneous; they were mostly round; only a few were oval or elongated, or oblong, with pointed ends and dumb-bell shaped. They were mostly isolated, here and there aggregated, and at one point forming a large heap. Their concentric layers were less evident than in the case of those found in the internal auditory canal.*

The above-described morbid conditions of the petrous bone were doubtless consequences of an early periostitis of the temporal bone, but whether congenital or appearing and developing in infancy we must leave under discussion. At all events, the hypothesis of periostitis explains in the most natural manner the pathological data, viz., the tympanic exostosis on the right side, the anchylosis of the chain of ossicles, the bony occlusion of both fenestræ rotundæ, the diminution of the vestibulo-cochlear space, and the bony coarctation of their intercommunication.

Whether the chalky concretions found on the vestibular sacs resulted from periostitis, or rom senile changes, or from mere accident, I must leave equally undecided. As far as I know, their occurrence at this place has not been noticed hitherto.

Notwithstanding the normal appearances of the ner-

* "Boettcher finds an explanation of the stratification of some of these bodies and the homogeneity of others in the circumstance that when the nucleus remains embedded in the dense tissue of the periosteum it is in the best condition to receive concentric additions from the connective tissue, but when, on the contrary, it is deposited at the internal surface of the periosteum, it developes rather towards the lumen of the auditory canal, which is not completely filled by the nervus acusticus. There the loose texture of the connective substance is less disposed to form concentric layers. The organic matrix becomes impregnated and finally covered with an incrustation, which conceals the inner stratified layers and gives to the whole a homogeneous appearance." Does not the peculiar position of the membranous sacs *of the vestibule* in the midst of the labyrinthine fluid explain why there is less tendency to concentric stratification of the concretions on the sacs?

vous apparatus, the perfection of the auditory function was impossible in presence of the above-described and very early changes in the sound-conducting apparatus.

The entire absence of any reliable history—not a matter of surprise in the present case—leaves us with no trace of a clue to the etiological points of this early periostitis. At any rate, this case adds another argument to the proposition that we are sometimes justified in seeking the anatomical substrata of congenital deaf-mutism in the peripheric mechanical part of the auditory apparatus.

It is of peculiar physiological interest that the tensores tympani showed no microscopic change. Although during the 64 years of this deaf-mute's life they had performed no function as regards audition, still there was no fatty degeneration. The explanation of this is furnished in the observation first made by Ludwig Mayer,* and afterwards confirmed by Kessel and others, that there is an anatomical continuity between the tensor veli palatini and the tensor tympani. The continual participation of the tensor tympani in the act of swallowing had prevented the fatty metamorphosis.

Case VIII.

Secondary syphilis. Total deafness on right side. Myringitis. Anchylosis of the ossicles. Adhesive inflammation in the labyrinth, with deposition of chalky concretions on the membranous semicircular canals and the sacs.

Gertrude Eppler, a seamstress of Heidelberg, 49 years old, entered the Academic Hospital (Friedreich's Clinique) October 16, 1871.

* Studies on the Anatomy of the Canalis Eustachii, by Dr. Ludwig Mayer. Munich, 1866.

She had had two normal deliveries, and had been out of health for six or seven years. In her 17th year she had suddenly become deaf and lost the sight of the right eye after washing her head while in a state of perspiration. Whether there was paralysis at this time could not be ascertained.

During the past six years she had been complaining of pain at the top of the head and parietal regions, and of vertigo. Five days before admission she had fallen in the street, and could still neither stand nor go about unassisted. Previous to this attack she was not paralyzed. Urine passed voluntarily; no stool for eight days. Had never been delirious (according to her son's account). Menses ceased.

Stat. præsens. She lies apathetic, comatose, with ptosis of the right lid; left pupil contracted and reacting very slowly. Head not hot; extremities cool. With the right hand she can press a little, but the left lies motionless. Both legs move at will, but pricking causes no reaction except on left foot. The teeth are clenched, but separable by means of a spatula. Masseters contracted; neither jerking nor spasms. Thoracic organs free. Heart's sounds normal. No atheroma of arteries. Spleen and liver not enlarged. Abdominal walls soft. Aortic pulse perceptible through the walls. No tumors. Vaginal portion of uterus hard, impermeable, not painful under pressure, and not swollen. Prescribed ice-bag, aq. laxat. viennens.; pulse 96.

Oct. 16. Evening, 38.8, 100. No passage. Breathing stertorous. Head hot. Urine passed in bed. Irido-keratitis on both sides.

Oct. 17. 36.2, 104. Two copious thin passages in bed. Wrinkles of left half of face disappeared. Left leg and left hand more sensitive than right. Reflex action everywhere equally good.

She lies apathetic, with closed eyes and small, weak pulse; urinates in bed, and swallows with difficulty.

Oct. 17. 37.2, 120. Very restless from noon till four o'clock, then apathetic again. Sensibility of left half of face diminishing, and left upper lid never opened again. Four passages in bed. Right radial pulse so imperceptible that it cannot be counted; left radial pulse better. Heart-throb still pretty strong, but the coma continues.

Oct. 18. 36.1 under left arm, 35.3 in the right axilla. No passage. Right arm cool to the shoulder, and its pulse imperceptible. Right

foot colder than left. Sensibility of right arm preserved, but lost in left foot. Same reflex action still. Considerable anæsthesia of left arm and foot. Resp. 20 per minute. No ronchi.

Eyes remained closed. It is ascertained that she was formerly treated for venereal disease. Deglutition impossible.

4.30 P. M. Continued deep somnolence.

Radial and cardiac pulse imperceptible. Extremities cool. From time to time a spasmodic inspiration, and death at 4.45 P.M.

Clinical diagnosis: Encephalopathy in consequence of syphilis.

More definite information from the deceased's friends revealed that for many years she had been quite deaf in the right ear.

The post-mortem examination was made Oct. 19.

Anatomical diagnosis: Atrophy of parts of right parietal bone in consequence of gummy tumors. Gelatinous œdema of pia mater. Hydrocephalus internus. Convolutions, especially on left side, flattened and anæmic; in the right corpus striatum a fresh diffuse hæmorrhage. Old syphilitic scars in the liver, especially at the periphery of the right lobe, and a smooth, stellate, cutaneous scar on the flexor side of the right arm. No other noteworthy lesion.

Right petrous bone. A moderate amount of fluid pus in the external canal; cuticle slightly swollen. No distinct line of demarcation at the inner end of the auditory canal and the drum-head. The latter grayish red, flattened; its superficial layers so thickened that the handle is quite imperceptible and the short process only faintly indicated.

Mucous membrane of middle ear pale, but thickened, and the malleo-incudal joint nearly solid. Stapes firmly grown to the fenestra rotunda. The membranous structures of the vestibule are so intimately attached to the periosteum by connective-tissue bands, that in some places it was very difficult to excise a small piece for microscopical purposes; this was particularly the case in the descending portion of the superior semicircular canals. The posterior membranous semicircular canal was only thickened, and not soldered to the periosteum.

The osseous portion of the petrous bone surrounding the posterior semicircular canal was remarkably dark, cut easily, and presented in its sections under the microscope the appearances so fully described by Rindfleisch in the second edition of "Pathological Histology," pages 519 and 520, as rarefactive ostitis.

Condition of the labyrinth. The microscopical examination of the semicircular canals and the membranous sacs shows them to be in different stages of inflammation. In those parts of the semicircular canals which could still be isolated (vide supra) the epithelium and connective-tissue membrane are no longer distinguishable; they were covered partly by innumerable large and small cells lying close together, partly by a coarse net-work of large capillaries. At certain points of the periphery the connective-tissue membrane was thickened by new-formed connective tissue. Strong bands of connective tissue, infiltrated with cells, project from the periosteum.

The greater part of the vestibular structure appeared to the naked eye yellowish white and thickened, and its original form and structure evidently much disordered. This appearance was due to the presence of a thick layer of connective tissue which covered the membranes everywhere. In some central points of the membrane, where the tissue was less opaque and more reticulate, the connective tissue was found to be infiltrated with cells.

Where the newly-formed connective tissue is most abundant there were seen numerous isolated, and in some places aggregated globular, chalky concretions. These were first described by Arthur Boettcher (Virchow's Archiv, Bd. XII.), as found in the internal auditory canal. We have minutely described these concretions in the preceding case.

The lamina spiralis membranacea was evidently changed; it had a lemon color, was much thickened, and appeared under the microscope very opaque, very vascular, and infiltrated with numerous small cells. Of its several zones only the dentate region could be made out.

The above-described anatomical lesions of the organ of hearing furnish a sufficient explanation of the total deafness during life. Leaving out of account the myringitis which supervened toward the end of life, deaf-

ness was due to the anchylosis of the ossicles and the chronic inflammation of the labyrinth. Very probably this condition resulted from secondary syphilis, although the necroscopic data would not of themselves point to it as a specific cause. As far as I know we have not as yet any reliable anatomical signs of syphilitic inflammation of the labyrinth. We know too little of the pathological anatomy of the labyrinth, and especially of its syphilitic lesions, to be able to decide this question.

Voltolini (Virchow's Archiv, Bd. XVII., Section 8) observed hyperæmia in the vestibule, in the beginning of the cochlea, and in the horizontal semicircular canal in a case of tympanic catarrh and probable periostitis in a syphilitic person. Gruber (Lehrbuch der Ohrenkrankheiten, S. 617) found in a syphilitic soldier who died of exanthematic typhus considerable hyperæmia of the tympanic mucous membrane and membranous labyrinth, which appeared to be a good deal thickened. The labyrinthine liquid was sanguinolent and abundant. But in this case it may be asked whether the lesions in the labyrinth should not be ascribed to the typhus. In the present case the labyrinthine lesions were of themselves quite sufficient to cause total deafness even if there had been no anchylosis of the ossicles, and I consider the labyrinthine lesions so serious that the most direct and energetic treatment could not have restored the lost function. Perhaps the chalky concretions in the membranous structures of the vestibule were consequences of the periostitis.

Case IX.

An exquisite case of cholesteatoma of the right petrous bone. Erysipelas of the face. Leptomeningitis-purulenta basilaris. Abscess of the right temporal and cerebellar lobe. Suppurative inflammation of the ependyma of the lateral ventricle.

Friedrich Reger, aged 20, a weaver, was admitted into the surgical clinique of Dr. Simon, July 7th, 1871.

In former years he suffered frequently from glandular swellings in the neck. He was otherwise healthy and strong. According to his account there has been a discharge from the right ear during the last three months, with entire loss of hearing on that side. About four weeks ago the region in front of and above the right ear became red, swollen, and painful spontaneously and to pressure. The patient came to the clinique to obtain relief from his pain.

In front of and above the ear is a red swelling, which gives fluctuation over the zygomatic process and squamous portion of the temporal bone. There is a profuse purulent discharge from the right ear.

In the cartilaginous portion of the canal is an opening through which the probe reaches denuded bone. The right half of the face is paralyzed, and has been so for a week.

Diagnosis: Ostitis of the temporal bone. An incision 1¼ inch in length, about 6‴ from the tragus and the helix, was made directly into the fluctuating part, the patient being under chloroform. The temporal artery was injured and ligated. There was an abundant flow of pus mixed with inspissated fatty lumps. The probe struck denuded bone at the place which it had reached through the auditory canal. Two little scales of bone as thin as paper were found in the pus. A thread was passed through the ear into the cavity of the abscess, and thence out through the wound. The latter was partially closed by sutures above and below.

July 8. High temperature* in the evening.

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* I pass by the record of temperature of this case.

The region of the wound was painful and slightly reddened.

July 9. Erysipelas extending to the right half of the nose and angle of the mouth. Nausea. Inappetency.

July 10. The erysipelas has reached the other side of the face. High fever, with headache.

July 12. The erysipelas has reached the neck. Fever and headache somewhat diminished. Quinine, 10 grains.

July 14. The erysipelas had disappeared from the face, but returns to it from the neck. Very high temperature. Quinine, 10 grains.

July 15. Stat. id. Patient is soporose. Ice-bag.

July 17. The face is swollen to a shapeless mass. Severe headache. The patient answers when spoken to in a loud voice. Quinine. Malaga. Ice-bag to the head.

July 20. Some improvement, but he is still very weak and not quite himself.

July 25. Stat. id. The wound looks well.

July 30. Stat. id.

Aug. 1. Temperature again increased. Frequent vomiting in the night, not from indigestion. Pulse, very hard, 64. Complains of severe pain in the frontal region, and is rather out of his head. At noon convulsions lasting about three minutes. Great restlessness. Perfect unconsciousness.

Aug. 3. Stat. id. Sometimes he is for a little while conscious, but usually appears apathetic. Complains of headache. No difference in the pupils. The wound still looks well.

Aug. 5. He takes no nourishment. Is unconscious, throws himself about in the bed, passes fæces and urine in bed. The left pupil is wider than the right.

Aug. 6. Death at 8 A.M.

Twenty-six hours later Prof. Jul. Arnold made the autopsy.

Rigor mortis slight; skin yellowish white; but little fat in subcutaneous tissue; muscles light brown. Heart normal, lungs hyperæmic and atelectatic in the lower portions, aerated in the upper; an old broncho-pneumonic focus at the apex of the right lung. Bronchi catarrhal. Spleen moderately enlarged and vascular, with large Malpighian bodies. Both kidneys hyperæmic, but otherwise normal. The liver ex-

hibits numerous fatty spots; the section has a fatty lustre. The bladder is very much dilated; urine yellowish and turbid.

In front of the right ear a long wound. Cranium thin but compact; its very thin diploetic layer is rather hyperæmic. Sutures normal. Dura mater tense and its veins stuffed with blood. The pia mater is also very hyperæmic, and shows at the top of the convexity two patches as large as peas, infiltrated with pus. Over the bony tegmen of the right middle ear the pia mater is adherent to the dura, and both are peculiarly discolored. On lifting the membranes from this place we find a tumor embedded in the petrous bone, which is greatly distended, and at various points perforated, viz.: (1) at the basis and in a backward direction, but without breaking through into the sinus, which showed the normal relations between wall and contents; (2) in an upward direction; and (3) in a direction forward.

The tumor itself is nodular, here and there dotted with little granules, and presents the lustre of mother-of-pearl. There was no similar appearance on the left side, and a careful examination made afterwards found nothing abnormal. At the place where the temporal lobe had been adherent to the petrous bone there is an abscess as large as a nut in the brain-substance. The right half of the cerebellum is almost entirely changed into a semi-fluid ichorous mass, which is in close proximity to the fourth ventricle.

The meshes of the pia mater and arachnoid covering the cerebellum, the chiasm, and the crura of the cerebrum, are thoroughly infiltrated with pus. The lateral ventricles are distended with turbid serum, in which float, especially on the right side, a great number of flakes of pus. Around the ventricles the brain-substance is green and soft. The right parotid gland and neighboring cervical glands are quite hyperæmic and infiltrated with serum. Nothing of interest in the larynx and trachea.

The pia mater spinalis, at least in the upper sections, is also infiltrated with pus.

Anatomical diagnosis: cholesteatoma of the right petrous bone. Leptomeningitis purulenta basilaris. Abscess of the right temporal and cerebellar lobes. Purulent inflammation of the ependyma of the lateral ventricle.

After the right petrous bone was removed from the cranium the naked-eye appearances indicated a changed condition of the intra-cranial portion. The bony mass was mostly replaced by a soft, laminated, pearly material, which presented a nodular surface—some of the nodules being as large as a walnut.

The tumor was found at the following points:

1. At the angle of confluence of the vertical with the horizontal part of the sinus lateralis; here was the smallest nodule, heart-shaped.

2. At the base of the petrous bone; here the mass extends over both declivities of the petrous, reaching as far forward as the region of the eminentia arcuata, and with its middle portion corresponding very nearly to the destroyed edge, along which the sinous petrosus superior formerly ran.

3. Of the eminentia arcuata only a curvilinear edge was left. In front of it the tumor rose to a height of $1\frac{1}{2}$,''' and when lifted by a sound it was found to occupy the place of the superior membranous canal and the vestibule.

4. Another mass occupied the place of the bony covering of the antrum mastoideum; and

5. Still another mass, the largest of all, lay in the place of the bony roof of the vestibule, tympanum, and ostium tympanicum tubæ Eustach.

A section through the petrous bone with a fine saw and a more minute examination showed that all of these apparently distinct nodules formed part of one mass, which extended through the entire petrous bone and occupied the majority of its canals and cavities.

Beyond the petrous bone the tumor extended into the mastoid process, occupying all its cells, through the antrum mastoideum into the tympanic cavity, and thence into the inner end of the external auditory canal, whose posterior-superior wall had disappeared. Membrana tympani entirely wanting.

The portion of the tumor occupying the mastoid process appeared to consist of three portions, or zones, diminishing in size, but increasing as regards intensity of coloration from without inward. The inner smallest portion, about as large as a pea, was dark brown. The portion which for size and situation may be called middle was of a lemon color, while the outer and largest zone was white. When treated with

ether and chloroform, the inner portion became somewhat lighter in color, and when tested for hæmin by chloride of sodium and acetic acid the result was negative. The microscope showed fatty detritus and a little cholesterine; the middle zone exhibited a greater degree of fatty degeneration, while the outer zone exhibited a mosaic of closely packed epithelial cells deprived of their nuclei.

The fossa jugularis was well developed, and its bony wall—corresponding to floor of tympanum—was intact.

The structures of the middle ear—malleus, incus, stapes, intrinsic muscles—all gone, and the labyrinth wall destroyed. The membranous sacs and ampullæ, as also the bony and membranous anterior, upper, and posterior semicircular canals were wanting. The tumor extended continuously from the external auditory canal back to the porus acusticus internus, forming part and parcel with the nodule described at 2. The tractus spiralis foraminulentus and the lamina cribrosa were gone; but the opening of the aquæductus vestibuli on the posterior surface of the petrous bone was distinctly visible. The nervus facialis was entirely destroyed as far as the first bend, and the nervus acusticus ended in a slender stump near the point where usually the modiolus of the cochlea begins. The lumen of the cochlea had become an irregular, sinuous space, with nothing left to distinguish its various parts.

In the consideration of this case, three questions present themselves: 1, how long had the tumor been growing? 2, how did it originate? 3, how came about the terminal disease, the leptomeningitis with cerebellar abscess and purulent inflammation of the ependyma of the ventricle?

In regard to the age of the tumor and its origin, the history of the case threw no light upon the early period of the disease. Certainly it had existed more than three months; but that, as in the case of Buhl,* it had

* Nobiling, Contributions from the Pathologico-Anatomical Demonstrations of Buhl. Baier. Arztliches Intelligenzblatt, 1869, No. 33.

existed from youth, seems very doubtful. If this had been the case the patient would certainly have been aware of it, and in some way called attention to it, despite his indifference and want of talent for observation.

At all events, the data in this case are not decisive as to whether the cholesteatoma may be classed among the congenital or the acquired changes of the auditory organ. The difference in size between the cells of such a mass and those normally lining the mucous membrane of the tympanum—a point upon which Buhl lays so much stress—cannot be decisive in itself, since the cellular arrangement of the tumor may keep pace with the general enlargement of the mass.

Perhaps the truth lies between these two views; perhaps sometimes the tumor is congenital, and sometimes acquired.

In regard to the terminal disorder, the question arises as to whether the acute meningitis (and abscess of the brain) which, as in Buhl's case, brought on a fatal result, was an immediate consequence of the caries and pre-existing tumor, or pyæmic from the external abscess, or in connection with the erysipelas?

The post-mortem condition of the pia and dura mater over the right tegmen tympani (adhesion and discoloration) gives an air of probability to the first suggestion; its pyæmic nature would hardly be accepted, considering the absence of chills and the good behavior of the wound to the very last hour. The connection of the meningitis with the erysipelas has some clinical foundation, since death from suppurative intracranial inflam-

mation in cases of erysipelas is not so very rare. Perhaps the local affection of the ear and the erysipelas united in producing this disastrous result.

Respecting the disappearance of bone-tissue caused by pressure of the tumor, the present case is one of the most extraordinary hitherto published.*

The examination of the left petrous bone revealed no abnormal condition.

Case X.

Emphysema pulmonum. Chronic bronchitis and broncho-pneumonia. Chronic pleuritis on right side. Chronic ulceration of intestine. Purulent catarrh of right ear. Caries of right petrous bone. Erysipelas of the face. Signs of severe brain-disease during life. Death in consequence of œdema of the brain. Absence of any intracranial disease more closely related to the ear-affection.

J. Ebert, a sailor from Neckarsteinach, was admitted to the medical clinic, Sept. 28, 1872, having been picked up by a police officer the day before in a state of insensibility. He was now 50 years of age, had been healthy in youth, and until quite lately able to work at his business.

It was difficult to get much information from him as to his history, but it appeared that several years ago he suffered repeated attacks of fever, and symptoms of an epileptic character, which last appeared about three weeks previous to his admission. Two years ago he fractured the right thigh.

Status præsens. He is in a miserable condition, poor, and covered with pediculi of all kinds. A thorough washing must precede any closer examination. The countenance expresses stupidity and sleepiness, and altogether he presents the appearance of a drunkard. Urine: specific gravity, 1024, and no albumen.

* Compare the case described by me in these Archives, Vol. II., Part 1.

Sept. 29, 36.8, 72—37.0, 68. Several baths yesterday and to-day have improved his appearance. Ordered infus. ipecac.

Sept. 30, 37.2, 72—36.8, 70. Examinatio: medium stature; somewhat wasted; thorax barrel-shaped; musculi scaleni; steruno-cleido mastoidei and pectorales well developed; slight œdema of lower extremities. Percussion sound clear on the right side, extending anteriorly farther downward. Area of cardiac dulness not accurately made out. At the back, the lungs extended down to the eleventh intercostal space. Weak respiratory murmur, with distinct fine râles and whistling. Heart-sounds rather weak, but normal in character. Liver and spleen not made out to be enlarged.

Oct. 1, 36.4, 68. Countenance somewhat cyanotic; there is a weak cough, with no expectoration. Ord. ipecac and good diet.

Oct. 2, 72. Fæces passed in bed; less cough. He is stronger, and his general condition improved.

38.0, 84. No stool. Headache. Feels sleepy. Urine partly passed in bed. In the right cheek there is a painful nodule as big as a walnut. Heart-sounds weak, especially over the tricuspid valves. Respiratory sounds everywhere very weak. No rhonchi. Feet œdematous. Urine sp. gr. 1024, and no albumen. Ord. ice-bag to head, ipecac with liq. ammon. anis.

Oct. 3. Urine in bed. No stool. Condition as before. Ord. infus. senegæ, with liq. ammon. anis.

39.2, 96. Some urine in bed. Tongue dry. No more complaint of headache, but of pain in the ileo-cæcal region. Abdominal muscles tense, and belly drawn in. Percussion caused pain on lower right side. Cough. A few rhonchi here and there. Liver enlarged, but spleen not. Still some œdema at the ankles.

Temp.	8 P.M.,	38.8
	10 "	38.0
	12 "	37.0
	2 A.M.,	36.2
	4 "	36.2
	6 "	36.0
	8 "	36.2

Oct. 4. 36.2, 84. No stool. Urine in bed. Less pain in ileo-cœcal region. Tongue dry. He seems to be less inclined to sleep, coughs a little, and complains of pain in right ear, which is discharging. Says he has had defective hearing four weeks.

3 P.M., 37.6.
6 " 36.6.

Oct. 4. Evening. 37.6, 88. He answers rationally and complains of pains in the limbs.

Oct. 5. 36.4, 72. Slept well last night, but complains of pains in the limbs; œdema gone.

37.0, 80. Tongue dry and coated. No stool.

Oct. 6. 37.0, 80. Had a good night, and feels better. Respiration easier. Percussion note everywhere sonorous. A few rhonchi. Heart-sound weak, but not altered in character. Tongue coated. Abscess of right cheek opened. Still some appearance of cyanosis. Complains of pains in the legs, but there is no œdema.

38.0, 100. Stool in bed.

Oct. 7. 37.0, 88. More cough; no expectoration

39.0, 100. Stat. idem. Urine passed in bed several times to-day.

Oct. 8. 37.0, 108. Pains in the legs; somnolency, and involuntary micturition in bed.

37.8, 96. One evacuation. Stat. id.

Oct. 9. 37.2, 108. He complains of severe pain in the legs. No stool. Otherwise same condition.

Oct. 10. 37.4, 100. He is somewhat stronger. His gait is better, but still quite unsteady. No œdema, no albumen, and less cough. Passed water five times in bed. He answers slowly, but correctly.

37.6, 80. Respiratory sounds weak; cough.

Oct. 11. 37.0, 92. Stat. id. Still some cough; one passage in bed.

38.0, 120. St. id.

Oct. 12. 37.8, 100. Drowsy again. Urine and fæces passed involuntarily in bed. No appetite. Percussion note everywhere sonorous. Cardiac limits ill-defined. Auscultation: respiratory sounds weak, crepitant râles. Tongue thinly coated.

38, 112. St. id. No stool; and no urine passed in bed.

Oct. 13. 37.4, 112. Drowsy most of the time. Takes no nourishment except when very much urged.

37.6, 92. Stat. idem. Fæces in bed. Urine sp. gr., 1024. No albumen.

Oct. 14. 37.4, 96. He looks better, but is evidently about the same as yesterday. One stool in bed. Attempt to walk more successful than hitherto.

37.6, 96.

Oct. 15. 37.0, 92. Stat. id.

37.4, 88. One fæcal evacuation in bed.

Oct. 16. 37.2, 96. Stat. id.

37.2, 88.

Oct. 17. 37.0, 96. His general condition appears somewhat improved; the cough is gone and the respiration is easier. But he still complains of pain in his legs, the appetite is poor, and the tongue coated. Passed fæces in bed.

37.2, 86.

Oct. 18. 37.2, 104. Stat. id. During the past three days there has been a considerable increase of purulent discharge from the right ear.

37.4, 112. Fæces in bed. Urine sp. gr. 1024, and no albumen.

Oct. 19. 36.8, 100. Stat. idem. Appetite very slight. Little cough. One voluntary fæcal dejection.

37.2, 80. Same state.

Oct. 20. 36.6, 100. But little cough, and no expectoration. Heart's action weak. Urine passed in bed.

37.0, 112.

Oct. 21. 37.0, 100. Stat. id. Urine in bed. One stool.

37.4, 100.

Oct. 22. 36.4, 100. Bowels moved twice in bed. Stat. id. Appetite slight, no cough. Ord.: decoction of cinchona.

Nothing is known with certainty as to the commencement of the discharge from the ear.

The general weakness in all the extremities has been, from the first, remarkable. Most of the time he is apathetic and quite drowsy, but

complaining neither of vertigo nor of headache. When unsupported he becomes dizzy and does not know where he steps. The pupils are normal; there are no symptoms of paralysis of any of the cranial nerves. He usually answers correctly, but appears to have an exceedingly weak memory. The countenance has a very anæmic appearance. The pulse is very small and easily compressible; the heart-sounds are faint. The belly is drawn inward. He continues to have involuntary discharges of urine and fæces. There are no signs of lesions of the internal organs. The clear percussion sound of the lungs overreaches even the normal limits. There is pallor of the mucous surfaces. He appears to be deaf on both sides, for he must be spoken to very loud, and the watch is not heard even when applied to the ear. There has been no delirium.

37.2, 92. Stat. idem. No stool.

Oct. 23. 36.8, 80. No stool. He sleeps most of the time.

37.0, 100. Stat. idem. Urine sp. gr. 1028, and no albumen.

Oct. 24. 36.8, 100. Increased discharge from the right ear. Otherwise no change. No stool.

37.8, 104. Urine sp. gr. 1028, and no albumen.

Oct. 25. 38.0, 112. Pulse small. Stat. id. One stool. He complains of a stinging pain in the right side; but no cause found.

Oct. 26. 37.8, 100. Had a bad night. Passed urine in bed. Bedsore. No stool. The pain in the right side is gone, and there is no rubbing sound—(pleuritic frottement). Lips remarkably pale. A little albumen in the urine.

At the visit to-day he indicated the right side of the head as the seat of pain. (Encephalopathy? Cerebral abscess?)

36.6, 80. Passed water in bed.

Oct. 27. 36.4, 80. No change. No appetite.

37.2, 100. Stat. id.

Oct. 28. 36.8, 88. Very drowsy most of the time; it is difficult for him to talk. When asked whether he felt pain, and where, he always pointed to the same spot on the forehead.

He complains of considerable dysphagia, and of pain when he attempts to swallow water. On account of pain near the right articulation of the jaw, he cannot open his mouth wide enough to permit a

thorough examination. Passed fæces in bed. Involuntary micturition. The right facialis, especially its lower branches, appears to be less easily excited than the left. Pulse very weak, thready.

39.6, 136. 8 P.M., 40.4. Patient lies in deep sopor. Was finally roused sufficiently to answer that he felt pain in the right side of the head. Urine in bed. Ord. : claret.

8	o'clock	40.2
9	"	40.0
11	"	39.8
1	"	39.2
3	"	38.6
5	"	38.4
7	"	38.2

Oct. 29. 38.2, 142. The same drowsiness.

There are two peculiar red spots on the face—one between the right angle of the mouth and the right eye, the other between the bridge of the nose and the canthus of the eye. One stool in bed. To-day he opens the mouth less widely than yesterday. When asked about pain, he indicated the right frontal region and the red spots on the face. One stool in bed. Urine 1030, and no albumen.

Oct. 30. 38.0, 120. The red spots have to-day a paler appearance, but have crossed the nose to the left eye ; the nose is swollen and painful to pressure ; the entire right half of the face is swollen and sensitive, and exhibits a scaly eruption. Pulse very weak, hardly perceptible. Cardiac impulse at the normal place, but very faint. In antero-superior parts of the right lung, moist râles ; in left lung, some rhonchi inferiorly. Urine in bed. Ord. : ice-bag.

Afterwards, at the clinic, the lung was found free. Thrombosis sinus lateralis ?

37.6, 120. Nose and upper lip largely swollen. Pulse very weak, and counted with difficulty. Involuntary discharges in bed.

Oct. 31. 38.2, 120. Œdema of right eye and lips, but no pain complained of when pressure is made here or elsewhere on the right side of the face. Involuntary micturition in bed. No change in the lungs. Pulse thready.

37.6, 88. Cardiac impulse very weak. Pulse scarcely perceptible,

and difficult to count. He cannot open the right eye; and the left ear is also swollen.

Nov. 1., 7 A.M. Respiration very labored; pulse imperceptible; surface cool; unconsciousness. Death at 8 A.M.

Autopsy (Prof. Arnold). Moderate rigor mortis; skin yellowish white; little fat under the skin; muscles light brown. Nose and entire right half of face infiltrated.

Calvarium thick, compact, and heavy; sutures normal.

A fresh clot in the sinus longitudinalis. Pia mater diffusely opaque and slightly infiltrated with serum. Both lateral ventricles contain more than the usual amount of clear serum. Ependyma singularly thick, and studded with little grains. In the depth of the anterior portion of the left corpus striatum a portion of the tissue is much softened, and of a peculiar grayish-yellow coloration; the surrounding tissue is grayish yellow (apoplectic scar). Ependyma of the fourth ventricle granular. General substance of the brain œdematous, moderately vascular, and its consistency diminished. Fresh clots in the sinuses of the dura mater; dura discolored over the right petrous bone. After removal of dura the bone is likewise found discolored. Meshes of the basal arachnoid infiltrated with serum and gelatinous substance.

The remaining lesions may be briefly included in the following anatomical diagnosis: *Chronic bronchitis and broncho-pneumonia. Emphysema on both sides. Recent lobular foci in the left lung. Chronic pleuritis on the right side, and sacculated collection of pus. Œdema of the brain. Apoplectic scar in the left corpus striatum. Chronic ulceration of intestines. Erysipelas of the face.*

Examination of the petrous bones. Right. External auditory canal and middle ear filled with pus. Lining of auditory canals, posteriorly and superiorly, bluish, much thickened, and easily separated from the bone. Perforation as big as a pea in the centrum of the membrana tympani; rest of membrane white and thick. Handle not perceptible. Tympanic mucous lining thickened.

Petrous bone carious at five places:

1. On the external surface of the mastoid process, close to the bony auditory canal, a dark spot as large as a bean, forming a pit-like depression which did not communicate with either the external auditory canal or the other carious points;

2. An opening as big as a pea directly over the antrum mastoideum; and,

3. About one half cm. behind the second, and twice as large;

4. As large as a pea, on the inner surface of the petrous, near the opening of the aquæductus vestibuli;

5. As large as a bean, at the basis of the petrous bone, at the confluence of the vertical with the horizontal parts of the sulcus lateralis. At this latter place the wall of the sinus was adherent to the bony canal by a quantity of newly-formed connective tissue; but in the canal itself no trace of inflammation or sign of phlebitis.

For the sake of saving the preparation, the other parts of the right petrous were not now examined. In a clinical point of view it was not important to examine the parts more minutely.

Left petrous bone. Auditory canal free. Drum-head grayish red and funnel-shaped. Handle not seen.

The mucous lining of the entire middle ear, excepting of the cartilaginous portion of the tube, hyperæmic and hypertrophic. Malleo-incudal joint covered by hypertrophied mucous membrane. Other conditions were not examined.

Without mentioning the former epileptic attacks, which were probably in close connection with the apoplectic scar in the left corpus striatum, there were symptoms enough for a probable diagnosis of a cerebral affection as a complication of the ear disease; the symptoms were not very much pronounced. Of course it is difficult to say, and indeed, in some cases, may be impossible to satisfy one's self as to whether the intracranial affection be a phlebitis or a thrombosis of a sinus, especially the sinus transversus, or an abscess, or some other brain-affection.

It is just that uncertainty of the symptoms, and our inability to attach them to any other morbid entity, which, according to Griesinger, authorizes us to suppose phlebitis of a sinus. In his essay upon otitic cerebral affections, in the "Archiv für Heilkunde," Bd. III., p. 447, he says: "According to reported cases the diagnosis of 'thrombosis of a sinus' becomes more and more probable by the larger aggregation of certain indeterminate symptoms of a cerebral character, which cannot be attached to any more easily diagnosticable morbid process. Hence the method of exclusion is practised. And when, after the post-mortem examination has demonstrated neither phlebitis nor thrombosis of a sinus nor abscess, our clinical and pathologico-anatomical experience is somewhat bewildered, we are not quite alone in the dark; for Cohn, in his "Clinical Treatise on Embolic Vascular Diseases," page 192, frankly confesses that "now and then, in spite of signs which to all probability indicate a cerebral disease, we find together with caries only œdema of the brain." The anatomical disposition of the parts was as favorable as possible to the occurrence of phlebitis of the right sinus transversus; for its wall lay directly over a carious opening (No. 5).

Case XI.

Gunshot wound of the skull. Caries of the base of the petrous bone. Phlebitis of the superior and the lateral sinus petrosus. Consecutive inflammation of the internal and the middle ear. Encephalitis.

Francis Picard, of Evensberg, Westphalia, a private in 82d Prussian infantry, was wounded at the battle of Wörth, Aug. 6, and on the 10th admitted to the surgical ward of the Academic Hospital.

Clinical diagnosis: gunshot wound in the temple, shattering the temporal bone. Acute encephalitis. Death, Aug. 23.

Autopsy by Prof. J. Arnold. Cadaver rigid; body strongly built and well nourished; skin yellowish.

There was a large flesh-wound behind the left ear, and another above the ear; in front of these wounds the soft parts were infiltrated with an ichorous substance.

The wound behind the ear led to a passage which took a forward inward direction through the posterior part of the squamous and neighboring part of the petrous bone, into the cranial cavity. The external plate of the perforated bone presented a jagged margin, while the internal plate was very much splintered at the expense of the lamina vitrea. Removal of the calvarium showed a considerable bloody extravasation between the dura and pia, especially at the posterior portion of the occipital lobe. The pia was very much injected, and contained extravasations over the occipital and temporal lobes. The brain itself at these points, and also the neighboring part of the cerebellum, showed the signs of red encephalitis. The changes do not extend deeply, for the diseased layer of brain-substance was nowhere more than 3‴ in depth. The mass of cerebrum and cerebellum was somewhat hyperæmic, but otherwise healthy. The wall of the sinus petrosus superior was discolored and covered with pus; but the sinus contained no thrombus. Same condition of sinus lateralis. In the other veins of the basis cranii only fluid blood and fresh clots.

Anatomical diagnosis: Gunshot wound in left temple: gunshot fracture of the temporal bone: phlebitis of sinus petrosus superior and lateralis: traumatic encephalitis. Metastatic foci in both lungs: suppurative pleuritis on both sides. Swelling of the spleen.

Examination of the petrous bone furnished the following data: At the place more minutely described above, a defect of bone as large as a nickel penny. The inner lower edge of the perforation was found at

the end of the descending portion of the sulcus lateralis, while the external edge was formed by that portion of the bone upon which the sinus petrosus superior runs to join the sinus lateralis. The upper margin of the hole is formed by the temporal bone. The base of the petrous bone thus exposed is covered with viscid pus and thoroughly carious. The uninjured part of the petrous is softened, yellowish, and easily permits the knife to penetrate to the bony semicircular canals. The tegmen tympani in the same condition. The mucous lining of the middle ear, as far as the bony portion of the tube and the mastoid cells, much hypertrophied. The uninjured drum-head is opaque and thickened, and slightly drawn inward; ossicles embedded in the hypertrophied mucous membrane; malleo-incudal joint movable; base of stapes hardly movable.

Microscopical examination of the labyrinth showed membranous structures thicker than normal and of a yellowish-white appearance; small-celled infiltration of the semicircular canals, membranous sacs, lamina spiralis membranacea, and of the connective tissue between the membrana propria of the semicircular canals and the underlying periosteum. The infiltration is most considerable posteriorly in the upper semicircular canals and the connective tissue lying between them and the periosteum; less marked in the remaining semicircular canals and sacs; least in the lamina spiralis membranacea.

The membranous wall of the aquæductus vestibuli is much reddened, and the microscope shows it to be covered with red blood-corpuscles.

There is nothing remarkable about the red softening of the brain or the inflammation of the sinus petrosus and lateralis. The changes found in the membranous aquæductus vestibuli doubtless resulted from its inflammation. The inflammation in the labyrinth and middle ear is to be considered a consequence of the injury to the cranium, appearing either at the same time with the inflammation of the bone or subsequently by a continuity of the inflammatory process.

The absence of thrombus from the inflamed vessels is nothing remarkable. It is most probable that the thrombus was molecularly disintegrated, carried into the circulation, and gave rise to the metastatic foci in the lungs.

It is remarkable that there was no blood in the inner ear; the explanation of this evidently lies in the fact that the injury to the petrous bone was by a glancing shot rather than by direct penetration. Concerning this compare my essay on gunshot injuries, in these *Archives*, Vol. II., Part I.

SUPPLEMENT TO THE DESCRIPTION OF AN IMPROVED LID-FORCEPS.

By H. KNAPP.

Since the publication of my description of an Improved Lid-forceps, in the first number of this volume, p. 257, the advantages of that instrument have been confirmed by continued experience. At the same time an alteration in its construction has proved useful. When the instrument is closed tight with the screw, its plate should not be at a level with the surrounding ring, but slant in such a way that its free lateral border (near *m* in the figure on page 258) projects about one line over the free lateral part of the ring. The elasticity of the plate and ring are thus taken into account, and when the instrument is used on the eye, the lid does not press the plate lower than to the level of the ring. But if plate and ring are at the same level when the unemployed instrument is closed, the free lateral part of the ring, when the instrument is applied to the eye, will project somewhat over the tarsal cartilage and be in the way of the operator. The slanting position of the plate, as recommended, obviates this inconvenience.

NOTE REGARDING A MODIFICATION OF SNELLEN'S ENTROPIUM-FORCEPS.

By DR. ARGYLL ROBERTSON, of Edinburgh.

With the view of overcoming what I conceived to be defects in the construction of the forceps devised by Dr. Snellen, of Utrecht, I got, in 1864, forceps made which differed from Dr. Snellen's in the following particulars: *First*, the handle of the instrument was applied at right angles to the lower margin of the plate. By this modification one instrument will suffice for both eyes; a saving both in expense and trouble is thus insured. *Second*, the narrow (or ring-) blade of the forceps was made to overlap the broad plate to such an extent that the inner border of the ring rested upon the outer border of the plate. *Almost* the whole margin of the lid could thus be exposed to the surgeon's knife, whereas, when Snellen's instrument is used, the parts at the margin of the lid covered by the narrow blade (corresponding in extent to its breadth) cannot be got at. The only other alterations were in the screw, which I got made much coarser, so that the pressure could be more quickly applied and removed, and in the nut, which was provided with projecting "wings" to enable it to be more easily turned.

This instrument I have employed in operations on the lids for the last nine years, and found it to answer

admirably. I have frequently exhibited it to oculists and surgeons visiting Edinburgh, and sent a specimen for exhibition to the meeting of the British Medical Association at Birmingham last year; but I must confess this form of the instrument has not come into general use in this country.

I was delighted to observe in the last number of the ARCHIVES that Dr. Knapp, recognizing the defects inherent in the shape of Dr. Snellen's instrument, had independently got forceps constructed similar to mine. In his, however, the narrow blade projects further beyond the broad plate than in mine, and thus stoppage of the circulation is due to bending of the vessels rather than to direct pressure upon them; but the object in both instances is the same, namely, to get more of the free margin of the lid exposed to the knife.

The advantages to be derived from these modifications in the form of Snellen's forceps are so obvious, that I am convinced these improvements will soon be generally adopted both here and in America.

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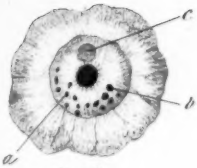

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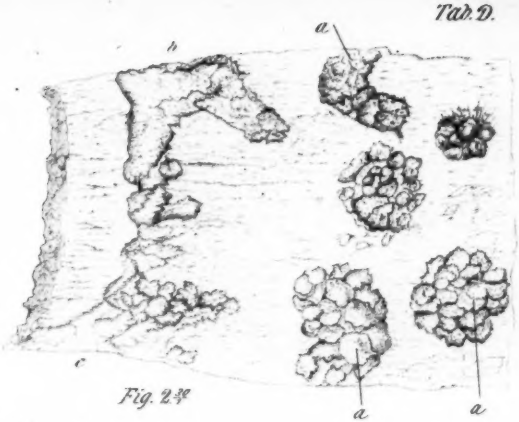

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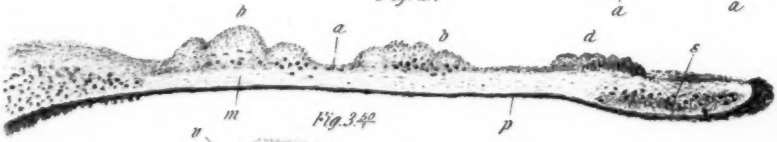

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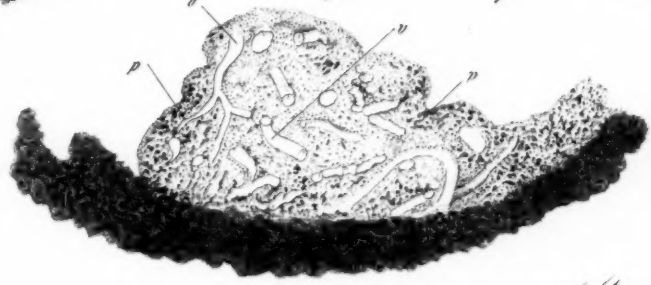

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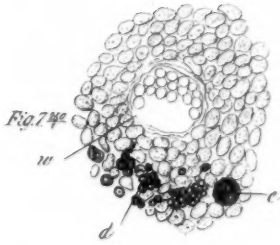

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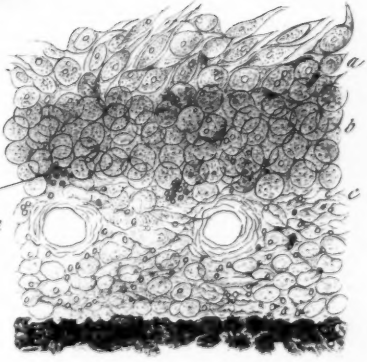

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Tab. E.

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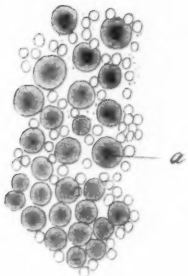

Fig. 2.

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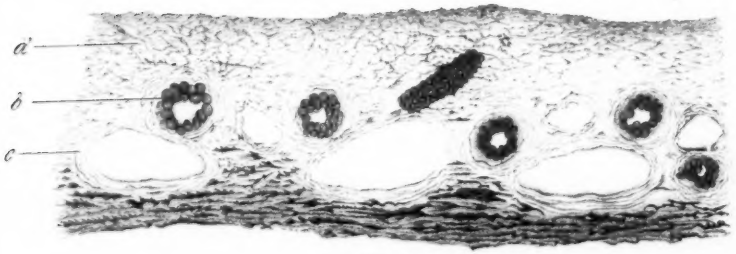

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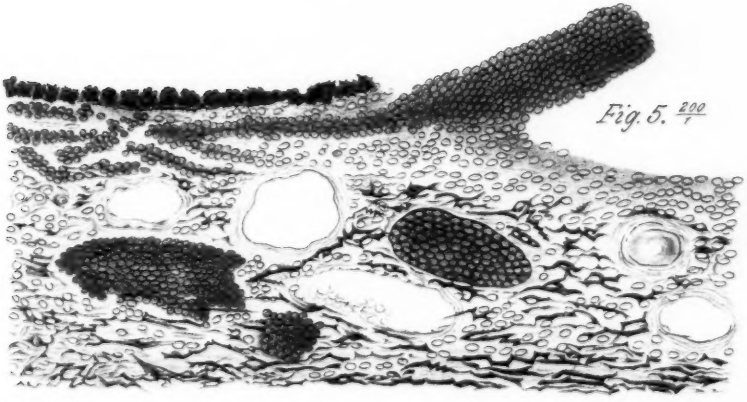

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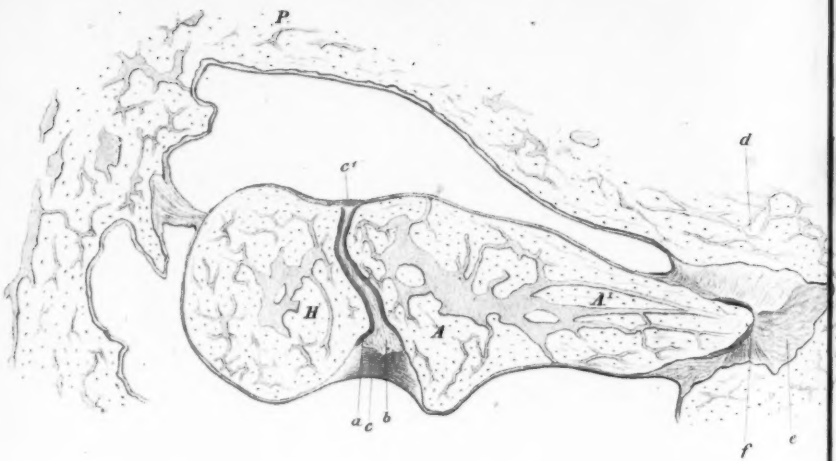

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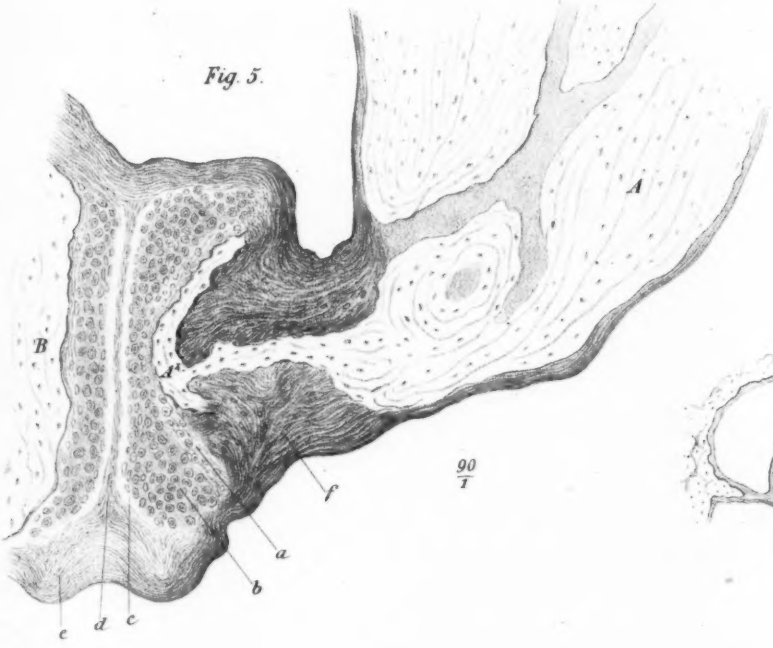

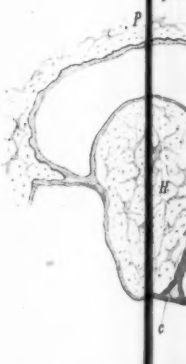

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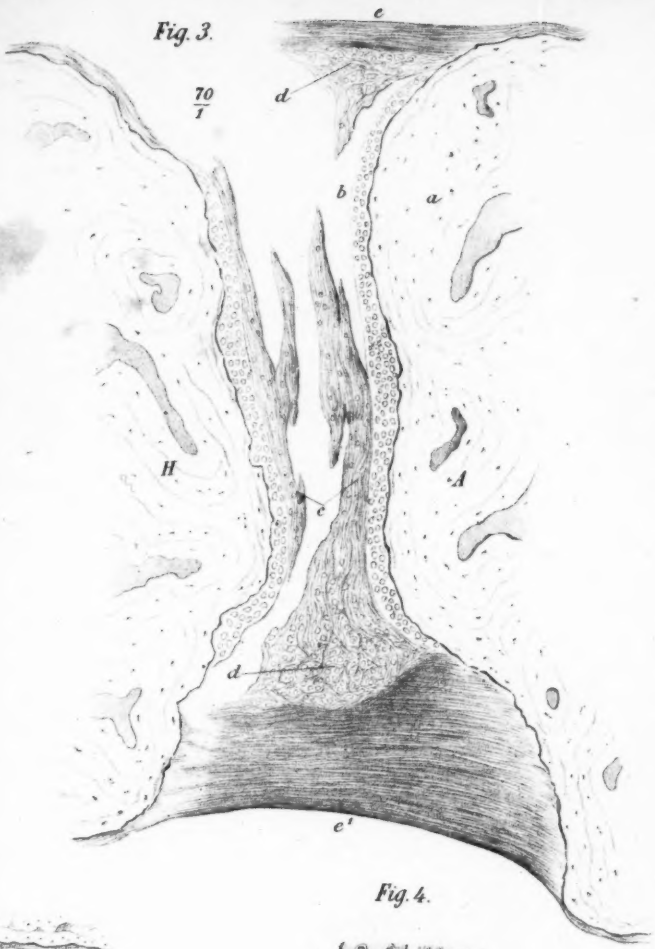

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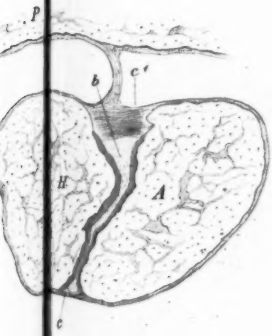

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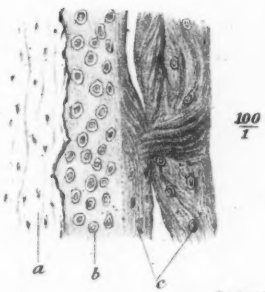

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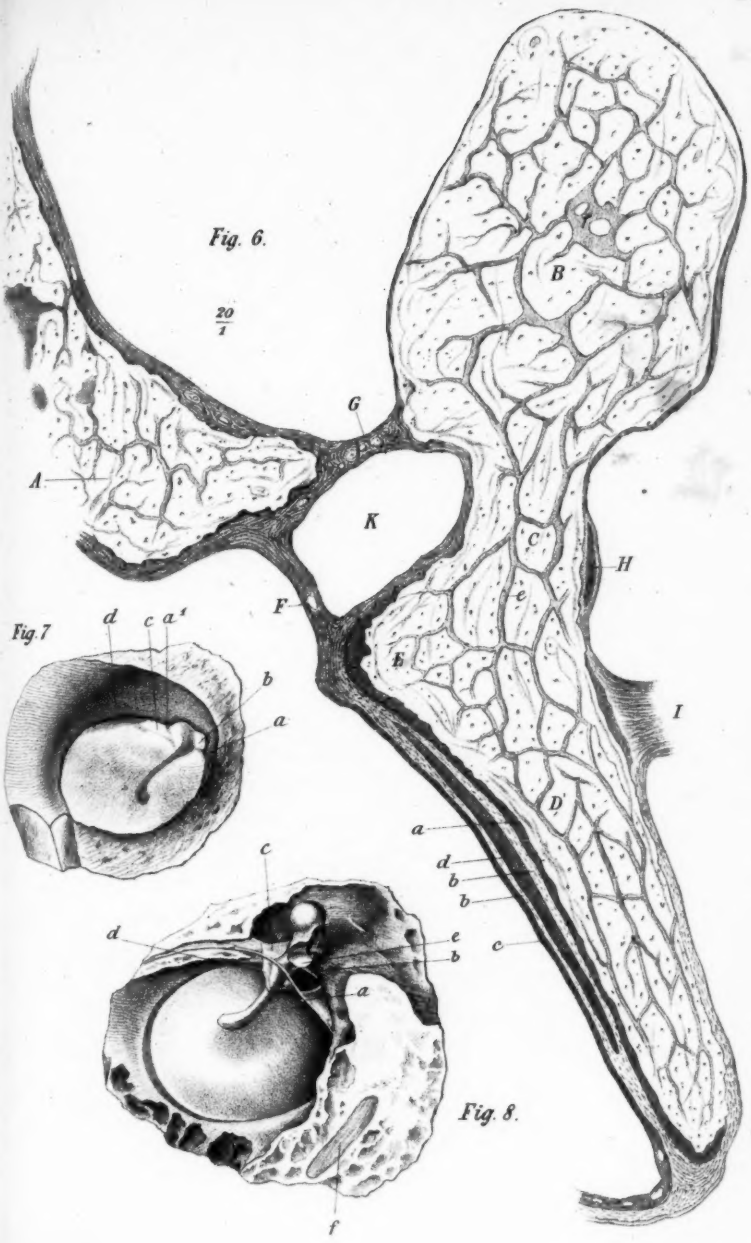

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